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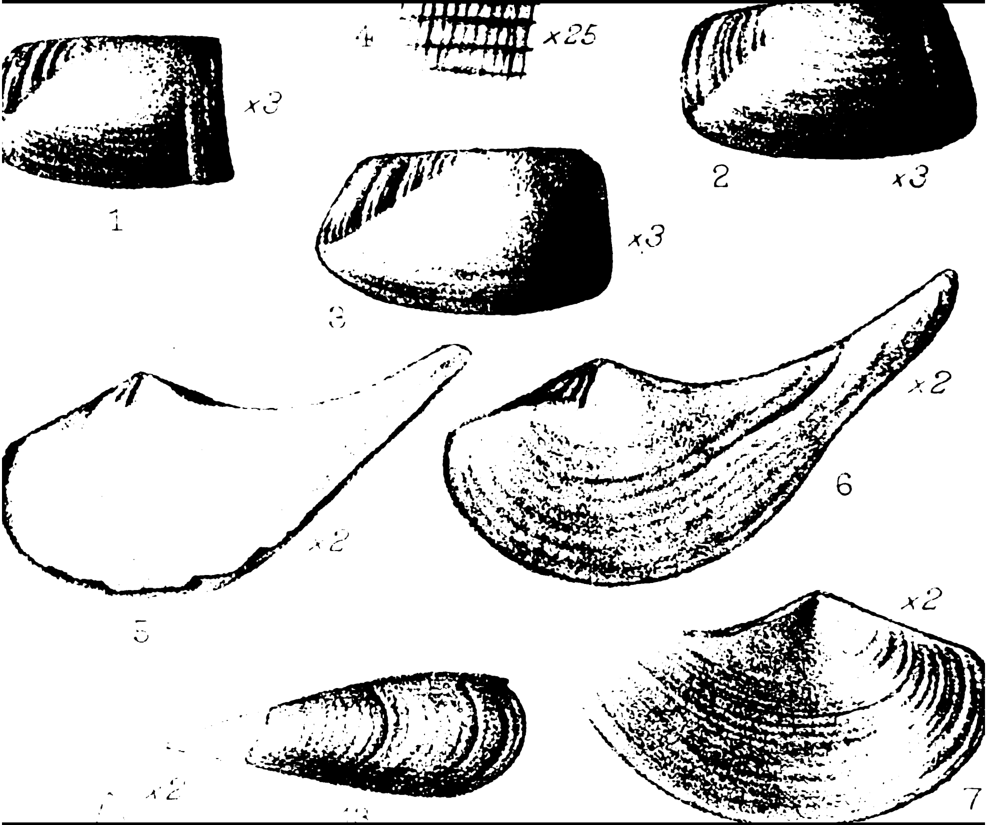

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THE

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OR

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WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., DR. GEORGE J. HINDE, F.R.S., &c., AND
HORACE B. WOODWARD, F.R.S., &c.

JANUARY, 1907.

CONTENTS.

I. ORIGINAL ARTICLES.

	Page
A Century of Geology, 1807–1907: The Geological Society of London. Portrait of President, Sir A. Geikie, D.C.L., Sc.D., Sec. R.S. (Plate I.)	1
Fossil Plants from the Carboniferous Limestone, Chepstow. By E. A. NEWELL ARBER, M.A., F.L.S. ...	4
The Volcanoes of Nevado de Toluca and Jorullo in Mexico. By BERNARD HOBSON, M.Sc., F.G.S. (Plate II.)	5
Pipe-Amygdaloids. By A. L. Du TOIT, B.A., F.G.S., Geological Survey, Cape Colony. (With 5 Figures.)...	13
Coastal Features, Fornaght Strand, Co. Waterford. By F. R. COWPER REED, M.A., F.G.S.	17
Evolution of *Stomatopora*. By W. D. LANG, M.A., F.G.S. (With 6 Figs.)	20
Some Clay Beds by the Ouse. By BERRY THOMPSON, F.G.S.	24
Fossiliferous Keuper at Bromsgrove. By L. J. WILLS, B.A., King's Coll., Cambridge. (With Sections.)	28
Bokkeveld Fossils. By F. R. COWPER REED, M.A., F.G.S.	34

II. NOTICES OF MEMOIRS.

	Page
The Limestone Knolls of Craven. By A. Wilmore, F.G.S.	36
Fossiliferous Drift Deposits at Kirmington, Lincolnshire. By J. W. Stather, F.G.S.	37

III. REVIEWS.

Memoirs of the Geological Survey ...	39
Summary of Progress of the Geological Survey	41
E. W. Berry on Fossil Plants	42
A New Geological Map of Ireland ...	43
The Bernese Oberland	43
Geological Survey of Western Australia	44
New York State Museum: Fossil Cephalopoda. By R. Ruedemann	45

IV. REPORTS AND PROCEEDINGS.

Geological Society of London—

November 21st, 1906	46
December 5th	47

V. CORRESPONDENCE.

Rev. O. Fisher	48

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AVES - - - - -	,, 12–15
REPTILIA AND AMPHIBIA - -	,, 16–21
PISCES - - - - -	,, 22
INVERTEBRATA - - - -	,, 23–24
RECENT SPECIMENS - -	3rd page of cover

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HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S., F.G.S.

LATE OF THE BRITISH MUSEUM OF NATURAL HISTORY; PRESIDENT OF THE
PALÆONTOGRAPHICAL SOCIETY;
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IMPERIAL SOCIETY OF NATURALISTS OF MOSCOW; OF
THE NATURAL HISTORY SOCIETY OF MONTREAL;
AND OF THE MALACOLOGICAL
SOCIETY OF BELGIUM.

ASSISTED BY

WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S., F.L.S., F.C.S.

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LIST OF PLATES.

PLATE FACING PAGE
I. Portrait of Sir A. Geikie, D.C.L., Sc.D., Sec. R. S., President of the Geological Society of London (1890–2 and 1906–8) . . . 1
II. Views of Volcanoes of Nevado de Toluca and Jorullo in Mexico . . 13
III. Portrait of William Whitaker, B.A. Lond., F.R.S. 49
IV. Crustacea, etc., from Girvan 109
V. Metamorphism of Chalk, Scawt Hill, Co. Antrim 148
VI. New Fossils from Haverfordwest 210
VII. Upper Cretaceous Fish-remains from Brazil 196
VIII. Section showing relations of *Ceratopyge* Series and underlying Beds, west coast of Öland, Sweden 257
IX. Erosion Pockets of 'Korrosionsgruppar,' Ulunda Stenbrot, Varnhems Kloster, Vester Götland 267
X. Sketch-map of Southern Scandinavia, showing distribution of Lower Palæozoic Rocks 296
XI. Remains and Impressions of Ears of Maize in Basalt, Morelia, Mexico 219
XII. Portrait of Professor H. G. Seeley, F.R.S., F.L.S., F.G.S., etc. . 241
XIII. Two new species of *Eurypterus*, Coal-measures, Ilkeston, Derbyshire 282
XIV. Plant-remains in Basalt, Bo'ness Coalfield, Linlithgowshire . . . 220
XV. Reconstructed Skeleton of *Diprotodon australis*, Owen 337
XVI. John Francis Walker, M.A., F.G.S. 380
XVII. *Lichas melmerbiensis*, sp. nov., Dufton Shales, near Melmerby . . 400
XVIII. *Pygocephalus Cooperi*, Huxley, Coal-measures, Coseley, near Dudley 407
XIX. Labyrinthodont Reptilian Remains, Upper Karroo, Cape Colony . . 436
XX. Fossil Plants from South Africa 481
XXI. Fossil Plants from South Africa 487
XXII. Eastern end of the Tygerberg Anticline, Cape Colony 489
XXIII. Photographs of thin slices of Ice, and reproductions of surface-markings on Glacier Ice in Ice-caves 529
XXIV. Reproductions of surface-markings on Glacier Ice in Ice-caves . 531

186676

LIST OF ILLUSTRATIONS IN THE TEXT.

PAGE

Pipe-amygdales from the Drakensberg 14

Vesicle cylinders in diabasic lava, Barkly West 15

Evolution of *Stomatopora dichotomoides* (d'Orbigny) 22

Section at Griffin's quarry, Rock Hill, Worcestershire 30

Prosopon Richardsoni, H. Woodw., sp. nov. 80

Geniohyus mirus, Andrews, right ramus of mandible 98

Saghatherium magnum, Andrews, left ramus of mandible 99

Section of Stonebarrow Cliff, Charmouth 151

Zone of *Hoplites interruptus* on Black Ven and Stonebarrow 153

Variation in thickness of *Hoplites* zone on Black Ven, Stonebarrow, and Golden Cap 155

Field of Eyepiece 172

Map of area of the Charleston Earthquake of August 31st, 1886 199

Skull of *Ophthalmosaurus icenicus*, Seeley 203, 204

Right fore-limb of *Ophthalmosaurus icenicus*, Seeley 205

Right ischio-pubic bone of *Ophthalmosaurus icenicus*, Seeley 206

Left hind-limb of *Ophthalmosaurus icenicus*, Seeley 207

Map of Blackheath and Greenwich District 213

Clathropteris egyptiaca, A. C. Seward, sp. nov. 253

Weichselia? sp. 255

Fragments of pinnæ of fern from Wadi Araba 256

Coracoid of *Metriorhynchus superciliosus* (Desl.) 317

Sketch-map of part of Zululand 347

Sketch-map of North-East Anglesey 349

Actinocamax Blackmorei, Crick, n.sp. 391

Actinocamax sp. 395

Restored figure of *Lichas melmerbiensis*, sp. nov. 397

Pygocephalus Cooperi? (Huxley), Coal-measures, Sparth (male individual) . . 405

PAGE
Pygocephalus Parkeri, H. Woodw., sp. nov. 406
Microphotograph of a collodion film 438
Section of Cliff at Newtown Head, Co. Waterford 502
Edge-view of pile of paper-strips 507
Same papers folded, showing displacement of lines 507
The same, showing the distortion of minor folds 508
Bellinurus Baldwini, H. Woodw., sp. nov., Coal-measures, Sparth, near Rochdale 540
B. longicaudatus, H. Woodw., sp. nov., Coal-measures, Sparth, near Rochdale 541
Eoscorpius (*Mazonia*) *Wardingleyi*, H. Woodw., sp. nov., Coal-measures, Sparth, near Rochdale 543
Geralinura Sutcliffei, H. Woodw., sp. nov., Coal-measures, Sparth, near Rochdale 545
Anthracomartus trilobitus, Scudder, Coal-measures, Sparth, near Rochdale . 548
Section of Drift at Head of Rathmoylan Cove 552

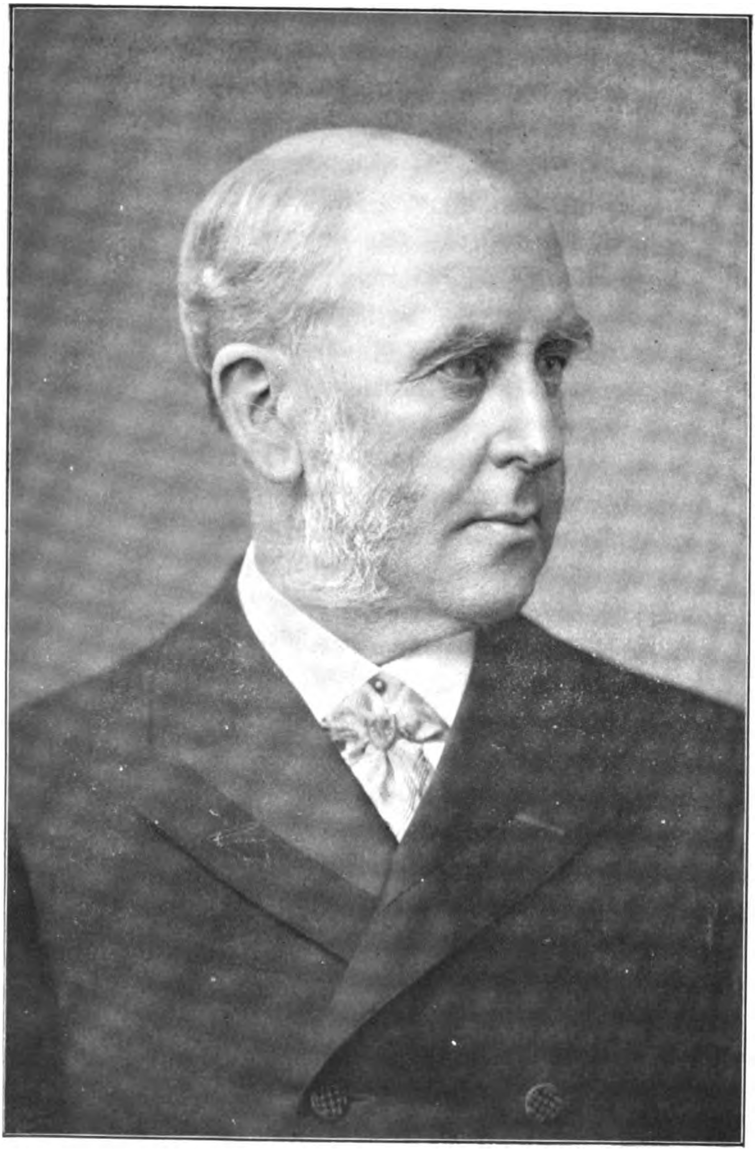
ERRATA.

p. 215, last line of right column of No. 3: *0* should be *6* (inches).
p. 308, line 15 from foot: *two last* should be *last two*. You can have but one last.—W. W.

[Mr. Buckman will feel obliged if the readers of the GEOLOGICAL MAGAZINE will kindly substitute the following corrected Memorandum for that in the September Number, p. 432.—EDIT. GEOL. MAG.]

PROCEEDINGS DORSET FIELD CLUB: DATE OF VOLUME IV. — This volume was issued without any date on the title-page; and the question has often arisen as to the correct date. Papers which it contains are dated [1883] in the Royal Society's Catalogue. However, the evidence for the date is to be found in vol. V, p. xv. An obituary notice of the Rev. H. H. Wood says: "He dies just as the 4th volume of the Proceedings . . . . is issued to the members." He died (p. xiv) on November 3rd, 1882, so that the end of October or beginning of November, 1882, is the date of the volume in question.

S. S. B.



Yours truly

Arch^d Geikie

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. I.—JANUARY, 1907.

ORIGINAL ARTICLES.

I.—A Century of Geology, 1807–1907.

The Geological Society of London.

(With a portrait of its President, Sir Archibald Geikie, D.C.L., Sc.D., Sec. R.S.)[1]

WE are glad to be able to present our readers with a portrait of Sir Archibald Geikie, F.R.S.,[2] the distinguished President of the Geological Society of London, who, on account of his very large and important contributions to our science, was last year unanimously elected a second time President of the Society in anticipation of its centenary, which will take place on November 13th, 1907, he having been deemed the most fit and proper Fellow to represent the Society as its chief officer upon so important and memorable an occasion in its history.[3]

In the earlier years of his geological career Sir A. Geikie spent the major part of his time in the Highlands and Lowlands, amid the glens, lochs, and mountains of his native Scotland, and although in Murchison's and Ramsay's days he passed many of his winters in London engaged on Survey work at Jermyn Street, it was not until he was appointed Director-General of the Geological Survey of the United Kingdom and Director of the Museum of Practical Geology in 1882, offices which he held until 1901, that he became an habitué of the Geological Society and a constant figure at its meetings.

In those days (from 1855) when as a youthful geologist of 20 he commenced his official work, and afterwards (1867–82) when

---

[1] For permission to use the present portrait we are indebted to the President and Council of the Royal Scottish Geographical Society, Edinburgh, in whose journal it first appeared.

[2] For a brief sketch of the life of Sir A. Geikie see Geol. Mag., 1890, pp. 49–51, with a portrait; see also "Who's Who," 1907.

[3] There have been forty-three Presidents in 100 years (six of whom have been once re-elected and one twice re-elected); G. B. Greenough having served three times (1807–13, 1818–20, 1833–5); and the following twice: Buckland (1824–6, 1839–41); Murchison (1831–3, 1841–3); Sir C. Lyell (1835–7, 1849–51); Leonard Horner (1845–7, 1860–2); W. J. Hamilton (1854–6, 1864–6); and Sir A. Geikie (1890–2, 1906–8).

Director of the Geological Survey of Scotland, however remote his field of work might be, his ever-active pen and pencil kept him in touch with the world at large. "The Story of a Boulder." "Gleanings from the Notebook of a Geologist" (1858), his "Memoir of Edward Forbes" (1861), "The Scenery of Scotland viewed in connection with its Physical Geology" (1865, 3rd edition 1901), and many other of his writings[1] were read with the keenest enjoyment.

We published in February, 1890, a portrait of Sir A. Geikie and a brief summary of his work up to that date, just prior to his election for the first time as President of the Geological Society. The addresses which he gave during the two years that he occupied the chair formed the nucleus of perhaps his most important work, published in 1897 under the title of "The Ancient Volcanoes of Great Britain," two volumes, beautifully printed and illustrated. In the same year he established the "Summary of Progress of the Geological Survey," an annual publication which gives an official record of the work done by this institution. He prefaced the first number with an account of the Origin and History of the Geological Survey and Museum, a subject which he had dealt with more personally in 1895 in his "Memoir of Sir Andrew Crombie Ramsay." While still Director-General he edited in 1899 a third volume of Hutton's "Theory of the Earth," from the MS. that had long been in the possession of the Geological Society.

In 1892 he was President of the British Association at Edinburgh, and in 1899 he was chosen for a second time President of the Geological Section at the Dover meeting. In 1900 he published an official memoir on "The Geology of Central and Western Fife and Kinross." In the following year he retired from the public service; but, as we intimated (Geol. Mag., February, 1901, p. 96), it was not his intention to lay aside either his hammer or his pen. In 1902 he brought out another Survey Memoir on "The Geology of Eastern Fife"; in 1903 he issued a fourth edition, in two volumes, of his "Text-Book of Geology," a work of 1,472 somewhat closely printed pages. From the severer side of science he turned to "Scottish Reminiscences," a volume published in 1904; and in 1905 he issued "Landscape in History and other Essays." Meanwhile, in 1903, he accepted the office of Secretary to the Royal Society in conjunction with Dr. Joseph Larmor, a position which might alone have given enough work for any man in the days of his *retirement.*

In the earlier days of the Geological Society, "the age of the demigods," but comparatively little was done by its members to interest the outside world. The Society was a *very select body*, and as one of its members observed at the time, the Council was practically the Society, and existed to publish its own papers, other peoples' opinions and papers being a negligible quantity.

---

[1] For original articles by Sir A. Geikie and notices of his writings, see the Geol. Mag., 1864, p. 22; 1865, p. 125; 1866, pp. 456, 549; 1867, pp. 171, 316, 465; 1868, p. 249; 1869, pp. 32, 129, 137; 1870, pp. 41, 136; 1871, p. 279; 1874, p. 81; 1878, pp. 49, 128; 1879, p. 278; 1882, p. 322; 1883, pp. 39, 47, 80, 238; 1888, pp. 42, 282; 1889, p. 32; 1891, p. 498; 1894, p. 188; 1895, p. 132; 1896, pp. 42, 481; 1897, pp. 233, 326, 371, 417; 1898, pp. 232, 306, 358; 1899, pp. 321, 452; 1901, p. 81; 1903, p. 273; 1904, pp. 133, 135; 1906, pp. 145, 193.

As the years passed the names of Greenough, Conybeare, Buckland, Fitton, Sedgwick, Portlock, Horner, Murchison, Lyell, De la Beche, Forbes, Phillips, and Sharpe commenced to attract attention, and the world began to take an interest in the science; the writings of Lyell especially attracted attention, and as he himself remarked at the Jubilee of the Geological Club in 1874, he had been condemned for his heresies from every pulpit in the country, but had lived to see as many parsons as laymen turn geologists.

From the Geological Society has sprung into existence the Geological Survey of the United Kingdom, with its staff of surveyors all over the country, producing annually maps and memoirs of the greatest value to our science. The Museum of Practical Geology and its Royal School of Mines soon became another living centre from which a steady output of young geologists went forth each year to conquer the earth. Nor may we forget that in addition to the Quarterly Geological Journal and the Society's Transactions has sprung into being the Palæontographical Society, with its grand array of monographs of British fossils (now 60 years old). E. Charlesworth's *London Geological Journal*, 1846–47, the *Geologist*, edited by S. J. Mackie, 1858–64, the GEOLOGICAL MAGAZINE, by H. Woodward, 1864 to the present time—all these have tended to help on the science of geology.

As Englishmen we have reason to feel justly proud of our William Smith,[1] and his first Geological Map of England; of his nephew, John Phillips, whom he trained up to be the future teacher of many, the author of the "Geology of Yorkshire," the Curator of the York Museum, the home of the Yorkshire Philosophical Society, which under Harcourt gave birth to the British Association for the Advancement of Science (now 76 years of age), that has done so much to promote geology as a study in these Islands; of Buckland, Sedgwick, Lyell, Murchison, Prestwich, Jukes, and the long list of their followers who have kept alive the flame of enthusiasm on the altar of our science through a hundred years. Nor must we forget that, born of the Geological Society, the Geologists Association (already 48 years of age) has arisen as a vigorous offspring of the elder Society, and is even stronger on its feet than the parent, travelling each year over the length and breadth of the land and extending its rambles into France, Italy, and elsewhere. Never had Britishers reason to be prouder of a scientific body than we of the Geological Society (just a century old), the doyen of all the Geological Societies of the world, from whose founders and followers have arisen so many living offshoots of working associations, publications, field clubs, and local societies. Copying the toast of a great city company we may exclaim "Long may it flourish and grow, root and branch, for ever."

---

[1] Styled by Sedgwick "the Father of English Geology" (see GEOL. MAG., 1869, pp. 356–359; 1870, pp. 301–303; 1873, p. 31; 1877, p. 378; 1892, pp. 94, 144; 1897, p. 439).

II.—A NOTE ON FOSSIL PLANTS FROM THE CARBONIFEROUS LIMESTONE OF CHEPSTOW.

By E. A. NEWELL ARBER, M.A., F.L.S., F.G.S.

THE occurrence of plant-remains in the Lower Carboniferous rocks of England is so rare that the recent discovery of impressions in beds belonging to that series at Chepstow, by my friend and pupil Mr. M. P. Price, B.A., of Trinity College, Cambridge, is worthy of record. Mr. Price has obtained several examples of a Sphenopterid frond and other plant fragments from a bed of sandy shale of about 4 feet in thickness, lying between a red sandstone below and limestone beds above, in one of the Pen Moel quarries on the left bank of the Wye, immediately to the north of Chepstow. This locality is mentioned in Dr. Vaughan's[1] recent paper on the palæontological sequence in the Carboniferous Limestone of the Bristol area. That author informs me that he refers the beds in question to the lower portion of the *Seminula*-zone (S_1 of his classification) on the evidence of the fauna.

Considering the sandy nature of the bed, the impressions are fairly well preserved. The most abundant plant is a leaf belonging to the frond-genus *Sphenopteris*, which, so far as I can judge, appears to be identical with *Sphenopteris Teiliana*, Kidston,[2] only known hitherto from the Lower Carboniferous beds of Teilia Quarry, Gwaenysgor, Flintshire. I have compared the Chepstow fossils with examples from the Flintshire beds in the Sedgwick Museum, and on the whole they agree very well. In some cases the dichotomous branching of the rachis, which is so characteristic of this fern-like plant, is clearly seen. The pinnules are indifferently preserved, but the best of them resemble fairly closely the specimens from Flintshire. The nervation is not, however, preserved; nor is it to be seen in the examples previously known.

There is also associated with one of these fronds a small fragment resembling a fructification, which recalls that figured by Mr. Kidston[3] from Flintshire as "the fructification of a fern." A stem structure possibly belonging to a fern-like plant is also represented, and shows traces of what may perhaps have been petiole-scars, but not very clearly. It recalls the appearance of a badly preserved *Megaphyton* in some respects. A branched rachis without foliage, and a small portion of an obscurely ribbed cast complete the list of specimens so far obtained.

The discovery of a new locality for *Sphenopteris Teiliana* is of interest. On the evidence of the flora from Teilia Quarry, Mr. Kidston inclined to the opinion that the Flintshire beds were the equivalents of the Calciferous Sandstone of Scotland. On the other hand, Dr. Vaughan[4] has shown that the fauna of the Chepstow deposits belongs to the higher series (Viséan) of the Carboniferous Limestone

---

[1] Vaughan: Quart. Journ. Geol. Soc., vol. lxi (1905), p. 251.
[2] Kidston: Trans. Roy. Soc. Edinb., vol. xxxv, pt. 2, p. 424, pl. i, fig, 3, 1889.
[3] Kidston: ibid., p. 426, pl. ii, figs. 8 and 9.
[4] Vaughan: ibid., pp. 251 and 186.

Series. It is quite possible, however, that this species may occur in both the lower and upper beds of the Lower Carboniferous.

The specimens[1] discussed here have been presented to the Sedgwick Museum by Mr. Price, who informs me that he hopes to make yet further collections from the Chepstow beds. Such should prove to be of considerable interest if well-preserved impressions can be obtained.

III.—An Excursion to the Volcanoes of Nevado de Toluca and Jorullo in Mexico.[2]

By Bernard Hobson, M.Sc., F.G.S.,
Lecturer in Petrology and Geology in the Victoria University of Manchester.

(PLATE II.)

In connection with the meeting of the Tenth International Geological Congress in the city of Mexico, an excursion, known as the Jorullo Excursion, was organised, of which the following is an account:—

Nevado de Toluca.

Under the leadership of Mr. T. Flores, geologist of the Mexican Geological Institute, a party of thirty geologists left Mexico city (altitude 7,432 feet) on August 20th for Toluca (altitude 8,761 feet), distant 46 miles by the Mexican National Railway. From a small hill close to Toluca an excellent view of the town itself and the extinct volcano of Xinantecatl or Nevado de Toluca (altitude, according to Flores, 14,973 feet), distant about 12½ miles to the south-west, is obtained. It lies at the southern edge of the great Mexican plateau (Mesa central), and has the form of an abruptly truncated cone, resembling that of Vesuvius before the eruption which destroyed Pompeii and Herculaneum. On August 21st we left Toluca by train for Calimaya, 11 miles distant and on the east side of the volcano. At Calimaya station we were met by a body of *rurales* or rural mounted police, armed with carbines, swords, and revolvers, who were to form our escort. They were holding horses for our use. We mounted, and rode at first by a gently ascending road through fields of maize and agaves (American aloes). The road then followed the bank of a barranca or stream-gully, which was dry. We dismounted to examine the excellent section exposed. The walls of the barranca were composed of well-bedded white pumiceous tuff, the lapilli varying in size from that of peas to that of a fist or larger. In one place the tuff was seen to overlie a bluish-grey bed of volcanic sand, in another the underlying bed consisted of soft black peat-like soil, but the most interesting point was the exposure in the vertical barranca-wall of a transverse section across a small stream-bed filled with pumiceous tuff differing slightly in colour and bedding-planes from the main mass, showing that water had played a part in the deposit of the almost horizontally bedded tuffs. Higher up we entered a pine forest, and climbed a shoulder whence a splendid view of the summit of the mountain and the surrounding country was obtained. After descending, with many windings, through most beautiful woods almost as much as we had ascended, we reached the Hacienda del Veladero, where we lunched. We then resumed our ascent, following the edge, crossing and then following the bottom of a deep barranca in volcanic tuff, until we reached our quarters for the night, two specially erected wooden sheds. Rising at 5 the next morning, after a somewhat sleepless night owing to the cold, we ascended through a pine forest amid wild lupines. The sun was rising, and through the beautiful foreground of pines we saw a magnificent view; the broad and flat plain to the east was filled with a sea of cloud, above which towered in the distance the snow-clad cone of Popocatepetl (17,876 feet) and the broader white summit of Ixtaccihuatl (17,318 feet). Abruptly the forest came to an end at 4,100 metres (13,448 feet), and we rode by a winding path on the treeless but grassy mountain side until we reached a cairn at one of the lowest points on the crater rim, whence we obtained a fine view of the interior of the crater with its central lava dome.[1] We rode down the interior slope of the crater to the shore of the Laguna Chica, the smaller of two lakes of crystal clear water, which is separated by the central lava dome from the Laguna Grande,[2] which is about 300 metres long by 213 broad and 10 metres in maximum depth, according to D. Joaquín Velazquez de León. The lakes lie at 4,270 metres (14,005 feet) above sea-level, hence the highest point of the crater rim, "Pico del Fraile," to which some of us climbed, rises 968 feet above their surface. The inner slopes of the crater have an average inclination of 30°, and are covered by screes to within a short distance of the rim: scattered patches of grass and wild flowers occur to a considerable height, above which are bare rock and scanty patches of snow. According to Dollfuss & Montserrat the elliptical crater measures along its major axis from north-west to south-east 1,431 metres (1,565 yards) by 595 metres (650 yards) along its minor axis. Mr. T. Flores regards the cone as built up of a series of lava-flows covered by pumiceous tuff and breccias. Some of the lava masses form prominent crags around the crater rim, but the tuffs form the main feature of the outer slopes of the cone, at any rate on the north and north-east sides. The final manifestation of volcanic energy was marked by the formation of the central lava dome. According to Mr. E. Ordóñez all the lavas are hornblendic hypersthene andesites. The evidence as to the age of the volcano cited by Mr. Flores does not appear to me quite convincing. He says that Mr. J. G. Aguilera[3] refers to the Upper Pliocene the pumiceous tuffs and breccias of the Las Cruces, Monte Alto, and Sierra Nevada range (separating the basin of Mexico city from the valley of Puebla), and Mr. Flores states that these tuffs correspond to those around the Nevado de Toluca, but apparently Mr. Aguilera does not give his reasons for assigning the tuffs he mentions to the Upper Pliocene. As Cretaceous limestones underlie the volcano and Pleistocene deposits overlie the argillaceous tuffs, which in turn overlie the pumiceous tuffs of the volcano, it may be considered to be of Tertiary age, and both Mr. Flores and Mr. E. Ordóñez believe it to have first appeared at the beginning of the Pliocene. No eruption is recorded as having occurred in historic times, and the mountain appears to have suffered considerable erosion. We rode down to Calimaya by a more direct path, and returned by train to Toluca the same evening.

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[1] Carb. Plant Coll., Nos. 1478–1484.

[2] For most of the facts in this paper I am indebted to two papers, "Le Xinantecatl ou Volcan Nevado de Toluca," par T. Flores, and "Le Jorullo," par E. Ordóñez, both forming part of the "Guide des Excursions du Xᵉ Congrès Géologique International, Mexico, 1906." An excellent general map of Mexico on which the route of the excursion can be followed is the "Carte du Mexique. Dressée au dépôt de la Guerre," par Mr. Niox, scale $\frac{1}{3000000}$ = 47·34 miles to 1 inch, date 1873, price 1 franc plus postage, from H. Barrère, 21, Rue du Bac, Paris. Of railways it shows only one, but the railways up to date are shown on Rand, McNally, & Co.'s *Indexed* Atlas of the World, Map of Mexico, scale 72 miles to 1 inch.

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[1] See Plate II, Fig. 2.

[2] See Plate II, Fig. 3.

[3] "Bosquejo Geologico de Mexico": Boletines del Instituto Geológico de Mexico, Nos. 4, 5, and 6, p. 229.

Toluca to Jorullo.

August 23rd. We left Toluca by train for Morelia (altitude 6,396 feet), 188 miles distant, passing on the way the saline lake of Cuitzeo, 45 miles long by 10 wide, but, like the rest of the Mexican lakes, very shallow, hardly more than 20 to 26 feet deep.

August 24th was spent in Morelia, and on the 25th Mr. Ezequiel Ordóñez, sub-director of the Mexican Geological Institute and Secretary of the International Congress, who was to be our guide to Jorullo, joined us. In the afternoon we left by train for Patzcuaro (alt. 7,183 feet), 39 miles away. Close to Patzcuaro is the beautiful lake of the same name (alt. 6,690 feet), about 12½ miles long and 23 feet in average depth. We walked from the town to the terrace of Los Balcones on the volcanic hill of El Calvario. From this point there is a splendid panorama of the lake, intersected by promontories, studded with islands and surrounded by basaltic cones so numerous, so graceful, and so perfectly preserved as to rejoice the heart of the geologist.

August 26th. At 6 a.m. we started, accompanied by an escort of *rurales*, to ride to Ario, about 28 miles away. After passing through maize fields we rode through the most beautiful park-like scenery, the hills on either side being all volcanoes, often beautifully preserved cones and either wooded or grass-grown from foot to summit. Volcanoes are as plentiful in Mexico as blackberries in England. At 8.45 a.m. we arrived at Santa Clara de Portugal, where maidenhair ferns grow like weeds on the old walls. On leaving it we passed through country which one might have mistaken for a bit of the English Lake District, but no lakes were visible, and on a near view the vegetation differed. We arrived at Ario (alt. 6,200 feet) at 2.30.

August 27th. We left Ario at 6 a.m. Our road was chiefly downhill; we were descending the southern escarpment of the Mexican plateau. The vegetation became more tropical; bananas, mimosas, and Opuntias were common, and small well-wooded volcanic cones were numerous. At 9.35 we reached Rancho Nuevo (alt. 4,593 feet), 11 miles from Ario. We left at 12.40 and continued to descend, passing through a pine forest. In an hour we were among fan-palms, and as we reached lower levels they increased in number. Here and there a Ficus had entwined its stem with that of a palm, and orchids grew among the branches. We passed the Hacienda La Playa, and descended to the bottom of the natural amphitheatre in which Jorullo lies.[1] Giant trees dropped their adventitious roots to the ground, climbing plants entwined their trunks, exquisite natural ferneries were on every hand, but what most delighted us was the abundance of streams and the greenness of the luxuriant tropical vegetation. At 5.15 p.m., after 15 miles ride from Rancho Nuevo, we reached the comfortable house at Mata de Platano, south-east of Jorullo, which the copper-mining Compañia de Inguaran had placed at our disposition.

At last we had arrived at the goal of our journey, the historic volcano, which first appeared in September, 1759, and was visited in 1803 by Alexander von Humboldt, whose description[2] has made it classic ground for the geologist.

Jorullo.

As already mentioned, Jorullo lies at the bottom of a great natural amphitheatre, 8¾ miles in diameter, formed by erosion in the Central Plateau, and with its concavity facing south. Within this amphitheatre the volcano stands upon a raised platform or minor plateau of old basaltic lavas, named the Mesa de la Higuera, the surface of which is inclined towards the south and west. On every side stand older basaltic cones, such as the Cerro Blanco, 1¼ miles to the south, Cerro del Bonete, 1 mile to the east, Cerro del Saucito, 1⅛ miles north-east, Cerro de la Cruz, 2⅛ miles north-west, Cerro del Veladero, 2⅛ miles west. Looking northward from the Pico de Humboldt, the north-eastern summit of Jorullo crater rim, one sees the escarpment of the great plateau rising over 3,000 feet above the floor of the amphitheatre and densely wooded; the western side of the amphitheatre is formed by the dioritic chain of Las Canoas, the eastern by the chain of Inguarán, while towards the south rise range after range of mountains until in the far distance the great Sierra Madre del Sur closes the view. Only immediately to the west of the cone is there a comparatively level space of 3¼ square miles covered by the lava-flows of Jorullo. Rising from the plateau of Higuera, and ranged in a line running from N. 35° E. to S. 35° W. true, stand four cones, not six as older observers reported. These are the vents of Jorullo, though only the largest of the four is properly so called, the other minor (not parasitic) cones being termed 'volcancitos' or small volcanoes.

The Chief Cone.

Although the highest part of the cone (termed by Ordóñez Pico de Riaño) reaches 4,330 feet above sea-level, Jorullo is not imposing from its size, for even on the west side it only rises 1,312 feet, and on the east side only 574 feet above its base. It is hardly an exaggeration to say that there are scores of nameless volcanoes in Mexico of equal size, though not of equal interest.

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[1] Humboldt mentions guavas (*Psidium pyriferum*), a fan-palm (*Corypha pumos*) now called *Copernicia pumos*, and an alder (*Alnus Jorullensis*) at the Playas de Jorullo.

[2] "Kosmos": J. G. Cotta'sche Verlag, Stuttgart, vol. iv (1858), pp. 334–348, and English translation by Otté & Dallas, Bohn's Library, 1865, vol. v, pp. 308–323.

It is of regular conical form, its summit broadly truncated by a comparatively large crater. Its sides slope at angles varying from 28° to 35°, the higher angle being met with on its southern and western sides. It appears most symmetrical as seen from the south, on which side, more especially, its slopes are traversed by numerous narrow, deep, and straight radiating furrows or barrancas due to erosion. It is most impressive as seen from the west, as on that side its height above its base is greatest. Seen from the west the latest (No. iv) lava-flow rises as a lofty black prominent and very conspicuous ridge forming an unsymmetrical appendage on the north side of the cone. (See Plate I, Fig. 1.)

To resume the account of our visit. August 28th. In the early morning we walked down the hill at Mata de Platano, crossed the stream at its foot, and followed a dry stream bed, in well-stratified black lapilli of Jorullo, to the east side of the cone, where the ascent proper began. The outer slope of the cone is composed of completely incoherent black lapilli mostly about the size of peas. In this soil grows from foot to summit of the cone a dense tropical vegetation of mimosas or acacias and other trees (reaching 15 or 20 feet in height), shrubs, grass, and maidenhair ferns. The grass does not form a continuous covering, but everywhere the lapilli are exposed, and nothing essential appears to be concealed, so that the luxuriant flora can hardly be considered a drawback by the geologist, while it greatly adds to the attractiveness of the ascent. We were half-way up the cone when a tropical downpour of rain began and lasted half an hour. The sky cleared and we soon reached the north-eastern summit of the crater rim which Mr. E. Ordóñez has christened Pico de Humboldt. From this point there is a splendid view of both the immediate neighbourhood and the more distant country.

The Crater.

The first feature to arrest our attention was the crater. It is ovoid in form, and measures along its major axis from north to south 568 yards by 421 yards from east to west, and its depth from the highest part of the rim is 489 feet. A breach 500 feet wide and about 200 feet deep has been formed on the northern side by the last outflow of lava. While the exterior of the cone consists of lapilli and agglomerate the interior of the crater forms an inverted conical cavity coated with lava weathered to a reddish brown and almost bare of vegetation. A series of curved fissures formed by the contraction of the lava in cooling has allowed the inner lava lining of the crater to sink in a series of terraces bounded by steep or vertical walls. The rim of the crater is a mass of very scoriaceous rough lava, very difficult to walk over, and in places very narrow. We made our way, however, along it to the west side of the rim, whence a bird's-eye view of the lava-streams is obtained.

The Lava-Streams and Fumaroles.

Ordóñez[1] gives an excellent geological map, scale $\frac{1}{30000}$ or 2·11 inches to 1 mile, of the Jorullo volcanoes (from which, curiously enough, all the watercourses are omitted). According to his map and description Jorullo gave rise to four lava-streams, which Ordóñez calls 'malpays,' literally 'bad lands.' The first and oldest of these was the most extensive, and each succeeding one was of less extent. The first flow was the first feature to be formed after the opening of the vent or vents, and like the second flow probably issued from the western foot of the Higuera plateau. It covered an area about 3,280 yards long by 3,060 yards broad, or approximately 3¼ square miles. The second flow covered a little more than half the area of the first, and in most places overlies its predecessor. The margin of the second flow forms a kind of wall 130 to 160 feet high. Ordóñez holds that not until these two flows had taken place did the vents enter on an explosive phase and form the four cones which we now see. The last two of the four lava-flows took place exclusively from the main cone of Jorullo itself by the breach already mentioned. Looking down upon lava-stream No. iii from the summit of the cone, we could clearly distinguish its margins and its black surface, and even trace the curves of flow of its surface, their convexity facing downstream and outlined by green lines of vegetation growing on it. The fourth and last of the lava-streams is so fresh and devoid of vegetation that I think personally it must be much later in date than the first. Its surface is not ropy, but exceedingly rough, scoriaceous, and of the 'aa' type of the Hawaiian volcanoes. Just outside the crater, the upper surface of the stream having solidified, while the still liquid lava within flowed on, a tunnel was formed in the lava, the roof of which ultimately collapsed and left a channel full of débris about 1,640 yards long, about 230 to 330 feet wide, with walls 16 to 33 feet high. This is called the "Calle de las Ruinas" or "Street of Ruins."

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[1] Loc. cit.

As already mentioned the latest lava-stream forms a prominent ridge, and its sides, far from lying in or accommodating themselves to a pre-existing valley, rise with almost wall-like precipitous steepness from the surface of the cone. Another noteworthy point, well shown on the map of Ordóñez, is the fact that all the lava-streams have flowed to the west or north and not to the east (except a portion of the latest stream). This westerly flow is due to the westward slope of the plateau of Higuera. Several fumaroles, which at present give off only steam at a temperature of 75° C., occur in the crater and on the latest lava-flow, and Ordóñez found a temperature of 165° C. at a depth of 1 metre in a fumarole on the last lava-flow.

The Volcancitos and Volcanic Bombs.

From the crater rim of Jorullo the volcancitos are well seen. Like the main cone, the volcancitos are composed of lapilli from the size of a nut to that of a fist, and like it too are clothed with verdure from base to summit. The Volcancito del Norte is about 1,500 yards north-east of the main cone, rises to 3,903 feet, or 377 feet above its eastern base (the plateau of Higuera); the Volcancito de Enmedio (middle cone) lies about 1,500 yards south-west of the main cone, rises to 3,411 feet, or 180 feet above its eastern base; while the Volcancito del Sur (southern cone), about a mile south-west of the main cone, rises to 3,592 feet or 394 feet above its base. In all three cases the western base is 180 feet lower than the eastern. Between the main cone and the Volcancito de Enmedio are several mounds of volcanic sand and lapilli, which have been regarded by previous observers as additional cones, but which, according to Ordóñez, show horizontal bedding-planes and not the structure characteristic of cones of eruption. The outer slopes of the volcancitos are as steep as those of the main cone, reaching as much as 35°. All three volcancitos are horse-shoe shaped, being breached on their western side. Mr. Ordóñez gives an explanation of this breaching which I find it difficult to accept. He says:[1] "En effet, ces cônes, peu élevés et d'un volume relativement faible, reposaient sur la lave, alors incomplètement solidifiée; et celle-ci dans son mouvement lent de descente, entraîna avec elle, la partie de ces édifices, qui avait pour base cet instable piedestal, et leurs pans détachés, perdirent l'équilibre et se réduisirent en morceaux." I should have thought it more probable that each was breached in the ordinary way by an outflowing lava-stream, but Mr. Ordóñez maintained that such was not the case, and time did not permit me to settle the question by an adequate examination of the ground.

The volcancitos are characterised by the abundance of volcanic bombs, which occur in their cones and appear to be absent from, or scarce in, Jorullo proper. These bombs are spherical, ellipsoidal, or fusiform, and sometimes show the fractured concentric layers known as bread-crust structure. They are mostly as big as a man's head, but may reach a cubic metre in size. On our way back from Jorullo to Mata de Platano on August 28th, we saw many excellent examples of them in the southern slopes of the Volcancito del Sur. On August 29th we left Mata de Platano and walked along the eastern foot of Jorullo, and then turned westwards along the southern side of the Volcancito del Norte and the northern edge of the latest lava-stream of Jorullo, afterwards crossing flows Nos. iii, ii, and i, which are more or less covered with vegetation which is not dense, the trees occurring scattered as in a park.

The Hornitos.

We examined several 'hornitos' (literally 'little ovens'). These are circular or elliptical mounds, generally perhaps 10 to 15 feet long and 3 to 5 feet high, consisting externally of numerous layers of incoherent small black lapilli or volcanic sand, each layer from one-fifth of an inch to 2 inches in thickness, arranged concentrically and parallel to the outer surface, forming domes with quâ-quâ-versal dip of the layers. Most of the hornitos have an opening through which gases and vapour formerly escaped, and they all contain a solid or hollow nucleus of the underlying basaltic lava.[2] They are simply surface vapour vents of the lava-streams coated with layers of volcanic sand and lapilli which, occurring in thick accumulations near the four cones, overspread the older lava-streams of Jorullo, but not the latest, which hence appears to be the result of the final effort of the volcano.

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[1] Loc. cit., p. 36.

[2] For details see the paper by Ordóñez already mentioned.

The hornitos do not agree with Humboldt's description, part of which is as follows: "Each of the numerous Hornitos consists of weathered balls of basalt, with pieces separated in concentric shells; I could often count 24 to 28 such shells. The balls are somewhat spheroidally flattened, and are mostly 15 to 18 inches in diameter; but also vary from 1 to 3 feet . . . .[1] The soft mass of clay which unites the balls is, strangely enough, divided into curved lamellæ, which wind about through all the interstices of the balls." In this description Humboldt appears to have been in error.

Petrography.

As to the petrographical nature of the lavas of Jorullo, according to Ordóñez they are olivine basalts, and there is no appreciable difference between the successive lava-streams. Specimens collected by me from the top of the main crater rim, the surface of the termination of lava-stream No. iv, and the lapilli of the main cone agree in essentials.

Phenocrysts. Olivine is present in all cases; augite, almost colourless in thin section, is less common; plagioclase (contrary to Mr. Ordóñez's observation "une première génération de feldspath manque presque complètement") occurs in numerous small phenocrysts (except in the lapilli). Brown hornblende crystals, with a dark resorption border, occur like phenocrysts (but may be inclusions). It was absent from the lapilli.

The groundmass makes up the bulk of the rock, and consists of small but idiomorphic crystals, viz., felspar laths, augite crystals, olivine, often reddish brown, and specks of black iron ore, all embedded in a brownish globulitic glass filling the interstices between the felspar laths and most abundant in the lapilli.

The older basalts of the plateau of Higuera and the older volcanic cones are distinguished from those of Jorullo by the presence in them of nepheline and hypersthene.

After examining the hornitos on August 29th we made our way to the Hacienda La Playa, whence we rode to Ario, and on the 30th to Patzcuaro, which we left on the 31st by train for Mexico, arriving there at 6.30 a.m. on September 1st.

Humboldt's Craters of Elevation.

Humboldt[2] considered Jorullo an example of one of Von Buch's craters of elevation due to the swelling up of a pre-existing surface. Of this there is not the slightest evidence. Mr. Ordóñez[3] thinks the eye-witnesses of the welling up of the earlier lava-streams of Jorullo were misled by them into thinking that the ground had risen in swellings.

The possible existence of a Line of Fissure.

Mr. Ordóñez, while not rejecting *a priori*[4] the hypothesis that the four cones of the Jorullo group are on a line of fissure, does not favour

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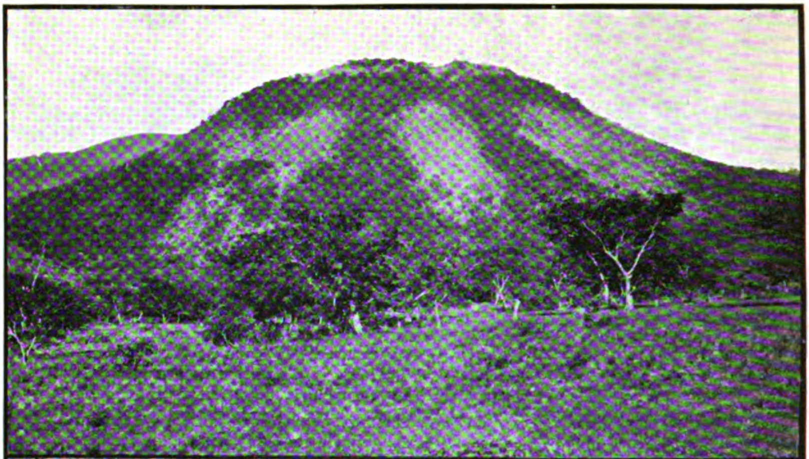
[1] I translate from the German edition of "Kosmos," vol. iv, pp. 340, 341 (J. G. Cotta'scher Verlag, Stuttgart, 1858); English version (Bohn's, 1865), vol. v, p. 317.

[2] "Kosmos," vol. iv, pp. 340, 336.

[3] Loc. cit., p. 42.

[4] Loc. cit., p. 22.



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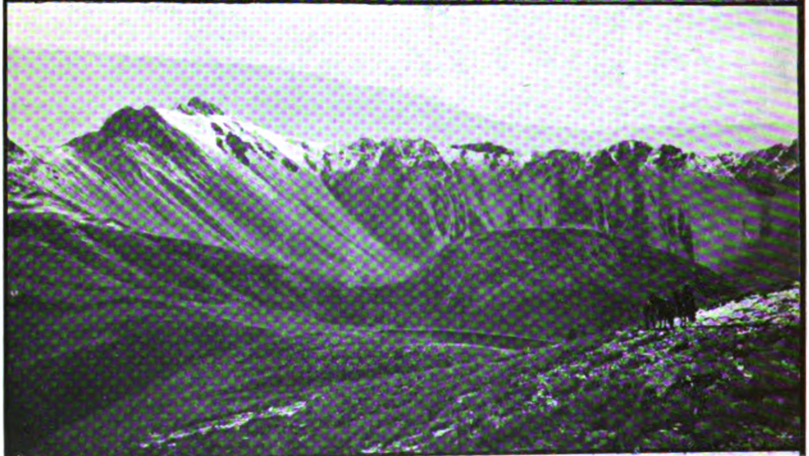

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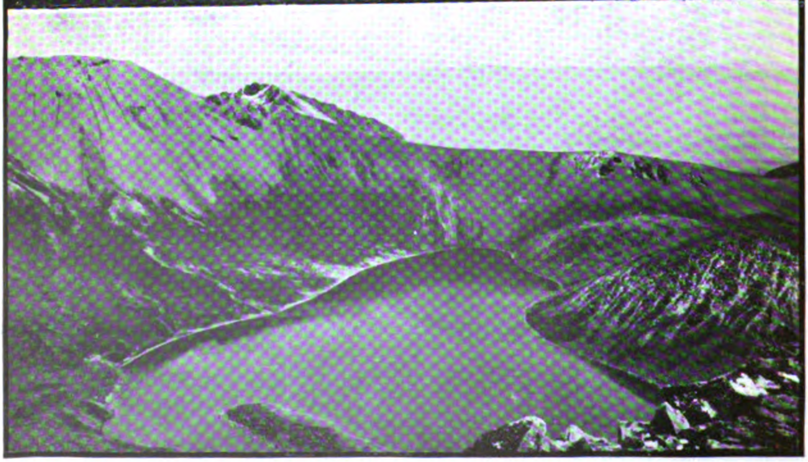

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FIG. 1.—Jorullo from the west. FIG. 2.—Crater of Nevado de Toluca.
FIG. 3.—Laguna Grande in crater of Nevado de Toluca.

it. He says:[1] "A peine le sable volcanique est-il emporté de quelque endroit immédiatement voisin des cônes que déjà, le basalte ancien des plateaux apparaît, dans sa position primitive, sans avoir éprouvé, par suite des éruptions le moindre déplacement. C'est pour cela que nous croyons que les cônes se sont formés autour de petits tubes, ou cheminées, et non sur une fracture continue." With regard to the No. i lava-stream he says:[2] "L'observation du terrain semble établir que, dans la formation du malpays le plus étendu et le plus ancien, ont participé des laves qui sortaient simultanément, des quatre bouches et qui, dans leur course, se sont fondues au point de ne plus constituer qu'un seul gâteau."

With all deference to Mr. Ordóñez I venture to tentatively suggest the following hypothesis. We may have here a most interesting example of the transition from fissure eruptions to crater eruptions. The lava-streams Nos. i and ii, each of which, as I understand him, cannot be separated into portions according to the vents which gave rise to them, may well have both issued from a fissure. This fissure being partially obstructed may then have retained four openings through which the fragmental materials of the four cones were ejected. Finally, the vent of the main cone alone remained open and gave rise to the last two lava-streams.

EXPLANATION OF PLATE II.

Description of Photographs.

Fig. 1, Jorullo. Figs. 2 and 3, Nevado de Toluca.

Fig. 1.—View of Jorullo from the magnetic west, showing its wooded slopes, the latest, No. iv, lava-stream issuing from the cone high up on the left, and in the foreground the park-like vegetation on the No. ii lava-stream.

Fig. 2.—View of the crater of Nevado de Toluca. The bridle-path leading down into the crater on the right, a part of the Laguna Chica with the central lava dome immediately behind it, and behind the dome the interior slopes covered with screes; and on the left the Pico del Fraile, or highest point of the crater rim.

Fig. 3.—View of the crater of Nevado de Toluca looking N.E. from high up on the S.W. crater rim. In the centre the Laguna Grande with the lava dome on the right, and in the right foreground part of a scree with patches of snow.

IV.—Pipe-Amygdaloids.

By A. L. Du Toit, B.A., F.G.S., Geological Survey of Cape Colony.[3]

PIPE-AMYGDALOIDS, although recorded in the Deccan Traps of India and in Tertiary Basalts from Mull, are rather uncommon rocks except in South Africa. They were described by Professor E. Cohen,[4] who obtained his specimens through Mr. J. Orpen from the Stormberg lavas (Lower Jurassic) of Basutoland, a formation in which they are very abundant. Since then they have been found in other volcanic formations, e.g., in the very ancient lavas of the Ventersdorp System in the Divisions of Kimberley and Barkly West, in the Bushveld Amygdaloid of the Transvaal and the Basalts of the Lebombo and Zululand (which all overlie rocks belonging to the Karroo System), and in the volcanic fissure of the Zuurberg in the Cape Colony (probably of post-Neocomian age). They have a striking resemblance to organic structures, and Cohen likens them to certain corals; in some exposures of lava the little pencils of white zeolite studding the surface remind one of the casts of worm burrows.

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[1] Loc. cit., p. 23.

[2] Loc. cit., p. 41.

[3] With the permission of the Geological Commission.

[4] Cohen, "Ueber einige eigenthümliche Melaphyr-Mandelsteine aus Süd-Afrika": Neues Jahrbuch, 1875, p. 113. "Mandelstein aus den Maluti-Bergen, Süd-Afrika": ibid., 1880, pp. 1, 96.

The pipe-amygdaloid never occurs in the middle or upper portion of a flow, only at the extreme base where the lava rests upon an earlier extrusion or upon sandstone or volcanic ash. In Barkly East pipes have been found in oval masses of lava embedded in sandstone or ash and representing bomb-like masses of molten rock ejected from neighbouring volcanic necks. Here too they only appear on the undersides of such masses and never on their upper surfaces.

The rock containing the pipes is usually a vesicular lava, but not necessarily so; sometimes the material may be quite compact without any other vesicles.

The amygdales are commonly from four to six inches in length, with about the diameter of a quill; sometimes they may reach about double that length. The vesicles are cylindrical in cross-section with occasional small swellings, and as they are traced upwards into the flow the tubes are found to unite, giving rise to a branching structure (Fig. 1).

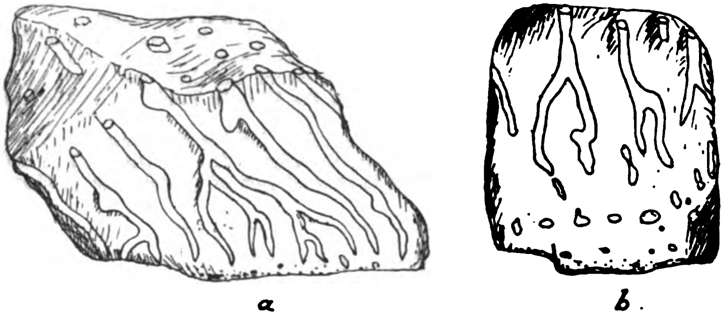

FIG. 1.—Pipe-amygdales in lava from the Drakensberg. In (*a*) the vesicles are inclined to, and in (*b*) are normal to, the base of the lava-flow. (Drawn about ⅓ nat. size.)

Larger tubes are also found, and are rather irregular in cross-section and constricted at points. The vesicles are filled in with calcite and chalcedonic silica in the case of the Ventersdorp lavas and with zeolites in the later volcanics.

Before discussing the mode of origin of these curious amygdales it will be of advantage to describe certain allied structures found in some of the compact diabasic lavas of the Ventersdorp System of Barkly West.

The lavas, which are buried almost horizontally here, are in places traversed by nearly vertical cylinders of amygdaloidal rock from one to six inches in diameter and with considerable length. Cross-sections are circular, elliptical, crescentiform, or a little irregular in outline; the spacing of these vesicular portions is usually very irregular.

The cylinder walls are clearly defined from the enclosing compact diabase, owing to the occurrence on their peripheries of closely-set vesicles elongated in a vertical direction; apart from their vesicular character, there seems to be no difference in the nature of the material composing them (Fig. 2).

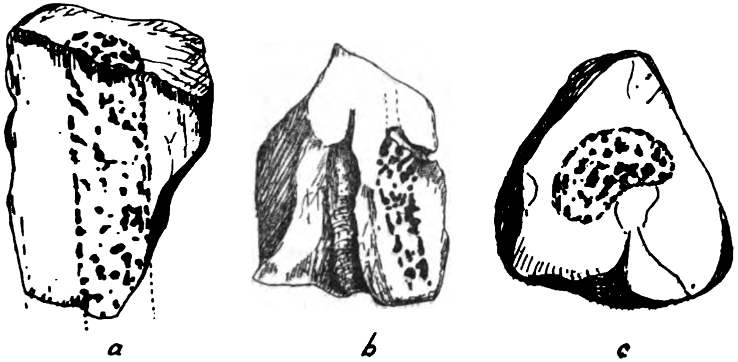

Fig. 2.—Vesicle cylinders in diabasic lava from Barkly West. (*a*) longitudinal fracture along, (*c*) transverse fracture across, a cylinder. In (*b*) a row of vesicles have coalesced to form a 'pipe-amygdale.' (Drawn about ½ nat. size.)

At the town of Barkly West a bed of this diabase rests upon an earlier extruded sheet of amygdaloid, and the lower eight or ten feet of the compact rock is traversed by many cylinders of vesicles. In some of the cylinders certain numbers of the bubbles have coalesced to form irregular pitted cavities, and in one case a long pipe-amygdale, about two-thirds of an inch in diameter, has been produced; ordinary pipe-amygdales are developed in places at the extreme base of the flow.

The cylinders may terminate sharply upwards in the form of a cone-shaped mass of vesicles, or the bubbles may become diffused through the diabase.

The vesicular portions of the rock are more readily attacked by weathering, and surfaces of the diabase exhibit shallow pits. At Niekerk's Rush, on the Vaal River, these hollows are so regularly spaced in the diabase along the river bank as to have led many persons to imagine them to be the footprints of prehistoric animals. The areas are D-shaped in plan and similarly oriented; the convex side apparently indicates the direction of a movement in the lava during its solidification.

Structures having a very great resemblance to, and in some cases apparently identical with, these have been described from the

Melaphyre of Darmstadt by Kuppers,[1] Klem,[2] Wittich,[3] and others under the names of "separation-bodies, contraction-cylinders, and bubble-trains." The lava being rather weathered, the cylinders break out from the melaphyre, but sometimes the continuity of the material still exists in places. Like the Barkly West examples these structures are only found in the lower part of the upper of two lava-flows, the rock above passing into a normal amygdaloid. Wittich explains them on the supposition that the upper portion of the second flow became chilled rather rapidly, so that the bubbles formed from the vapour given out in the lower portion were unable to escape. Kuppers, on the other hand, considers them as due to contraction during solidification. Neither of these views seems to account satisfactorily for the Darmstadt examples, nor will either of them hold in the case of the Barkly West specimens, occurring as they do in a rock which is otherwise devoid of amygdales.

I think there can be little doubt that the gas which filled the vesicles in these structures has not come from the lava-flow itself, but has been derived from cavities and fissures in the rock underlying. The lava being in most cases too mobile for the successful production of pipe-amygdales, the bubbles have ascended from the bottom in continuous rows and thus formed 'bubble-trains.' Vertical sheets of amygdaloidal rock in the diabase probably indicate that the gas has been emitted from a long fissure, while its evolution over a wider area would account for the masses of vesicular material of irregular outline and several square feet in section occasionally seen. It is perhaps even possible that with a great irruption of gas from below, a lava-flow that would otherwise have been compact might in great part become converted into amygdaloidal rock.

The gas may have consisted either of the air entangled in the lower lava-flow or of steam formed by the vapourising of water contained in it or else overlying it. In the case of the Ventersdorp lavas there is not sufficient evidence to show whether they were subaqueous in character, although certain interbedded quartzites point in that direction. The Stormberg lavas, however, contain towards their base intercalations of sandstone, shale, and volcanic ash, and the earlier flows have undoubtedly been erupted subaqueously.

Professor Schwarz[4] has attempted an explanation of the pipe-amygdales based upon Wittich's views, but I think that there is more likelihood of their having been formed by the steam generated in the flowing of the molten rock over moist surfaces; this is the theory adopted to explain the Indian examples.[5]

As Cohen pointed out, the condition essential to the formation of these elongated amygdales was that the lava should be sufficiently viscid. In thin sections of the amygdaloids the vesicular cavities rarely show evidence of having originated prior to the crystallization of most of the felspar; more commonly lath-shaped plagioclases and in many cases prisms and granules of augite project into the hollows.[1] This shows that the lavas as they issued from the volcanic pipes consisted of viscous and partially crystallized material.

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[1] Kuppers: Centralblatt für Min. Geol. u. Pal., 1901, pp. 481, 609; 1902, p. 521; 1903, p. 409.

[2] Klem: ibid., 1903, p. 217.

[3] Wittich: Tschermak's Min. u. Petrogr. Mitt., vol. xxi (1902), p. 185.

[4] Schwarz: Ann. Rep. Geol. Commission for 1902, p. 57.

[5] Medlicott & Blanford: "Geology of India," 1893, p. 261.

In hand specimens the actual base of a flow containing pipe-amygdales for a distance of from a quarter of an inch up to two inches contains small vesicles, or as one may almost term them 'undeveloped pipes.' Above this, where the temperature of the rock would have been greater, the lava is crowded with tubular vesicles which run into one another as they are followed upwards and give rise to a branching structure. After these terminate we may find elongated or irregular vesicles, evidently 'pipes' that have risen bodily through the lava and have become more or less modified by movement and temperature. Sometimes similar amygdales are found above these, but as a rule at a distance of a few feet above the base of the flow the normal rock, vesicular or compact, is found.

Commonly the pipes are arranged perpendicularly to the base of the flow, but sometimes, and this is commonly the case in Barkly East, the amygdales are much inclined. Deviations up to 60 degrees from the normal are found, indicating motion of the lava during their formation.

In some parts of the Drakensberg pipe-amygdaloids are very abundant; close to the town of Barkly East there are over a dozen horizons within a thickness of not more than 200 feet of rock.

An interesting parallel to the way in which I have supposed the pipe-amygdales to have been formed is afforded by some experiments of Messrs. J. I'Anson & E. A. Parkhurst.[2] Bubbles of carbonic acid gas carrying with them some sulphuric acid were allowed to rise through a solution of an alkaline silicate, and formed in their upward passage peculiar delicate, irregular, and branching tubules of colloidal silica much resembling corals.

V.—Notes on some Coastal Features in Co. Waterford.

I. Fornaght Strand.

By F. R. Cowper Reed, M.A., F.G.S.

THE occurrence of 'submerged forests' on the coast of co. Waterford has long been known, though no mention of them was made in the Survey Memoir published in 1865. The more recent discovery of pre-glacial beaches and raised wave-cut rock-platforms along the south coast of Ireland between Baltimore and Carnsore Point[3] has thrown still further light on Post-Tertiary movements of the land-margin; and accordingly some new observations on these phenomena in a hitherto unmarked locality may be of interest.

On the west side of the broad mouth of the River Suir there is an unfrequented bay bounded by Creadan Head on the south and

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[1] Ann. Rep. Geol. Commission for 1904, p. 134.

[2] Min. Mag., vol. v (1884), p. 34.

[3] Muff & Wright: Geol. Mag., Dec. IV, Vol. X (1903), p. 501; Sc. Proc. Roy. Dublin Soc., n.s., vol. x (1904), pp. 250–324; "Geology of Country around Cork" (Mem. Geol. Surv. Ireland, 1905, p. 36 et seq.).

Knockavelish Head on the north. The straight stretch of sand and shingle across the head of the bay is known as Fornaght Strand, but on each side the cliffs of the promontories descend abruptly into the sea without any beach exposed at their base, except a narrow strip at low tide in a few coves on the south and a mass of tumbled rocks on the north.

Two typical glaciated valleys, of which the southern one is the larger and longer, unite at the back of the flat expanse of marshy land which lies behind the strand at a slightly higher level; and they are separated by a ridge of Old Red Sandstone, which is the formation composing the whole surrounding area. This median ridge is particularly interesting because it ends abruptly at a distance of over 200 yards from the present sea-margin in a steep slope with a vertical cliff at its base, and in this way descends suddenly to the level of the alluvial flat. That this cliff has been produced by marine erosion and is in fact an old sea-margin is strongly supported (1) by the existence of an old rock-platform preserved beneath the drift deposits at the north end of the strand, and (2) by the occurrence of distinct traces of the same feature as a shelf cut in the face of the massive Old Red conglomerate cliffs of Knockavelish Head, which bounds the bay on the north. This shelf must be regarded as the much reduced remnant of a rock-platform; its continuity has been interrupted by subsequent erosion and its width narrowed to 3 to 4 feet. It stands at a height of about 10–15 feet above the shore-platform which is now being formed by wave-erosion, and at about 4–5 feet above the present high-water mark. The level of this rocky ledge corresponds roughly with the base of the inland cliff above mentioned, though the latter seems rather higher owing to the subsequent accumulation of superficial deposits round its foot. On the opposite side of the bay this rock-cut terrace cannot be well traced, probably owing to the nature of the cliffs of Creadan Head, which consist of nearly horizontal soft sandstone beds at sea-level with occasional intercalated thin bands of conglomerate, so that they have been rapidly undermined and worn away. But inland up the Creadan valley traces of the old sea-cliff can still be observed.

Returning now to the north end of Fornaght Strand, we find a line of cliffs running for about 150 yards nearly at right angles to the trend of the Old Red southern flank of Knockavelish Head. They rise gradually from sea-level to a height of about 40 feet at their northern end, where they end abruptly against the headland. These cliffs are composed of sand, gravel, 'head,' and Boulder-clay banked up against the solid rock of the northern flank of the valley, and they rest on a platform of Old Red conglomerate and Ordovician slates and flags which slopes up gently northwards. This platform is well levelled, and forms the old plane of marine erosion at the base of the inland sea-cliff, though its extension inwards to the latter is covered by the drift and other deposits of the alluvial flat. The subsequent erosion by the sea of the northern side and floor of this partially filled valley has caused the formation of this interesting section in the drift deposits. The actual junction of the latter with the solid rocky side of the valley is somewhat obscured by slipped material and rainwash, and overgrown with vegetation. But it is most suggestive of the source of the bedded materials in the cliff to find that the deposits, though somewhat irregular and impersistent, dip away from the valley-side towards the south or S.S.E. at an average angle of 15°, and thin out rapidly in the same direction, thus agreeing with the present surface contour of the valley floor and with the top of the cliffs. The following succession of beds can be best traced (in descending order) at a distance of about 30 yards from the northern corner of the bay, but they undergo considerable changes in character and thickness or even disappear when followed south, as noted below:—

	Feet.
(1) Soil, occasionally containing cockle-shells scattered irregularly or in patches, especially where the cliff is low at its southern end	⅓–1
(2) Yellow loam or clay with a few subangular and rounded stones, thinning out northwards and becoming indistinguishable from the bed below, into which it also passes down	3–5
(3) Dark brown stony loam ('head'), sandy and with fewer stones near top, but mostly filled with angular fragments rather closely packed, from the size of a pea to 3 inches in length; interstices filled with loam; distinctly bedded, but varying in coarseness. Thickens northwards. Rests on irregular (? eroded) surface of bed below. Continuous for whole length of cliffs	3–4
(4) Brownish Boulder-clay, unbedded, containing a few large stones or boulders. Thins out rapidly northwards, but increases rather suddenly in thickness southwards and then forms base and lower half of greater part of cliffs	1–20
(5) Loamy clay containing few boulders at top, where it passes imperceptibly up into No. 4, but in its lower part the stones (which are mostly subangular and of all sizes up to 8 inches in length) become more numerous, and are quite irregularly distributed irrespective of size, though sometimes obscurely arranged in parallel lines. At the base of the bed they are cemented together in places by iron oxide ('ferricrete'). The whole bed is thickest where No. 4 is thinnest, and rapidly wedges out and disappears to the south below the typical Boulder-clay. A large lenticular mass of white sand is a conspicuous feature in one place	0–15
(6) Wedge-shaped bed of small, loosely packed, flat fragments of slate averaging ¼ inch to 1 foot in size with rounded edges and arranged in definite layers; interstices filled with a little loam. Bed thins out rather rapidly to south and becomes inseparable from the base of No. 4, which there rests directly upon it. At its base there are a few large irregular blocks of Old Red Sandstone conglomerate, one measuring 3 feet by 1 feet	0–3
(7) White sandy loam passing down into fine, yellow, argillaceous sand without any pebbles or boulders. Sharply marked off from Nos. 6 and 8	3–4
(8) Coarse, sandy, and argillaceous gravel, composed of pebbles from Old Red Sandstone conglomerate	4

The greater part of the cliffs, however, does not exhibit such a full and varied sequence of deposits, and in fact only consists of beds 4, 3, 2, and 1, the southerly dip having carried the others (where they have not already thinned out) below the present beach-level.

Comparing the full succession of beds with that described by Messrs. Wright & Muff as resting on the Cork pre-glacial terrace, we may fairly recognise in beds 8 and 7 the equivalent of their 'raised beach gravel and sand' and perhaps of the 'blown sand' of many of their sections. Bed No. 6 may possibly correspond with their 'Lower Head,' though this bed and No. 5 are rather different in their development and show more sorting of the materials by water, suggesting a rearrangement of the 'head' or a modified rainwash, perhaps in early glacial times, so that they ought to be reckoned rather as stratified early glacial gravels. The thickening, however, of these beds towards the valley-side and the development of 'ferricrete' at their base, together with the inclusion of large tumbled masses from the old cliff at the base of which they accumulated, are points in common with the deposit termed 'Lower Head' on the Cork coast. The Boulder-clay, No. 4 of our section, followed by the 'Head,' No. 3, agree precisely in their relations, and to a large extent in their general characters, with those of Cork. It should be remembered, moreover, that there is considerable variation even along the latter coastline in the character, development, and sequence of deposits as described by the above-mentioned authors, and that a precise correspondence of the beds on Fornaght Strand can scarcely be expected. The important features insisted on by Messrs. Wright & Muff are the buried rock-cliff and the wave-cut rock-platform; and in the characters of these and the height above the present plane of wave-erosion and of high-water mark the correspondence is so close that we cannot doubt that we are dealing with the same features and phenomena.

A late downward movement[1] of the coastline is indicated by the 'submerged forest' of Fornaght Strand, which does not appear to have been previously noticed, though Hardman[2] in 1873 referred to the one near Tramore as a "partially submerged or silt-covered bog," and Kinahan[3] mentioned various submerged bogs (including the latter one) on the south-east coast of Ireland.

The shore of Fornaght Strand shelves very gently down to the sea, and about 30 to 40 feet from high-water mark (horizontal distance) the edge of the sheet of peaty soil appears in which the tree-stumps are rooted. It forms a wide flat, sloping down slightly and extending to an unknown distance seawards below low-water mark, even at spring-tides. It is often covered up with sand and not visible near the beach at ordinary low tides. The tree-trunks measure 1 to 1½ feet in diameter at the level at which they are broken off, which is, as usual, fairly uniform and close to their base. About thirty rooted stools were counted by me on my last visit there this Summer.

VI.—The Evolution of *Stomatopora dichotomoides* (d'Orbigny).

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

ALECTO DICHOTOMOIDES was the name given by d'Orbigny[4] in 1849 to a specimen figured by Michelin[5] in 1841 from the

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[1] Geikie: Pres. Add. Geol. Soc., 1904, p. xcvi.

[2] Hardman: Journ. Roy. Geol. Soc. Ireland, n.s., vol. iv (1877), p. 31 (read December, 1873). See also Geol. Mag., 1874, pp. 210–215.

[3] Kinahan: "Geology of Ireland," 1877, p. 265.

[4] A. d'Orbigny: Prodrome de Paléontologie stratigraphique universelle, 1849, vol. i, p. 288; and Paléontologie Française, Terrains Crétacés, vol. v (1854), pp. 834, 835.

[5] H. Michelin: Iconographie Zoophytologique, 1840, pl. ii, fig. 10.

Bajocian of Bayeux, or of Moutiers, Calvados, Normandy, and identified by Michelin as *A. dichotoma*, Lamouroux.

Haime[1] recognised d'Orbigny's name, and under it figured a specimen from the Aalenian of Postlip, north-east of Cheltenham, Gloucestershire, in the Walford Collection, now in the Sedgwick Museum, Cambridge. Haime's type, however, differs slightly from Michelin's figure, having larger and less pyriform zoœcia. But the chief point to be noticed is the extreme simplicity of characters in both.

In a paper[2] on the Liassic forms of *Stomatopora* three lines of descent were traced upwards as far as the *capricornus* zone of the Lias. Two of these stocks were already differentiated to such an extent that it cannot be supposed that *S. dichotomoides* (d'Orbigny) is descended from them; for the simplicity of this species shows no signs of being secondary. It is probable, therefore, that this Aalenian form is the direct descendant of the third series, of which the last term was *S. Gregoryi*, mutation *capricornensis*, Lang, from which *S. dichotomoides* (d'Orbigny) differs only in the greater pyriformation of the zoœcia.

Form 3—the Bajocian form—is the type of *S. dichotomoides* (d'Orbigny), so that Form 2 would be called *S. dichotomoides* (d'Orbigny), mutation *Murchisonensis*, according to the nomenclature advocated in the former paper, because it occurs in the zone of *Ludwigia Murchisonæ*. Otherwise the specific names remain unaltered.

It is to be doubted whether Vine's form *S. intermixta* differs at all from the type of *S. dichotomoides*. His type of this species and of *S. Phillipsi* cannot be found, though his collection is in the British Museum. But his figures of *S. intermixta*[3] and of *S. Phillipsi*[4] remain, and cannot be ignored. The diagram of *S. Smithi* is taken from the figure in the British Museum Catalogue.[5] The type is in the York Museum.

The only form of which sufficient material is available for tracing the changes in characters during the life-history is in the mutation *Murchisonensis*, of which Haime's type of *S. dichotomoides* is a good example. The following description defines this form:—

Zoarium loose and spreading, branching only after Type I.[6] The angle at the first dichotomy is 180°, after which it diminishes regularly to about 45° at the sixth dichotomy. The number of peristomes between each dichotomy is generally one, sometimes two. There seems to be no regular sequence in the variation of this character. The length of the zoœcia at the first dichotomy is about 2½–3½, increasing to 3½ at the third dichotomy and gradually decreasing again

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[1] J. Haime, "Description des Bryozoaires fossiles de la formation Jurassique": Mém. Soc. géol. France, ser. II, vol. v (1854), pp. 163, 164, pl. vi, fig. 2.

[2] W. D. Lang: GEOL. MAG., 1905, p. 258.

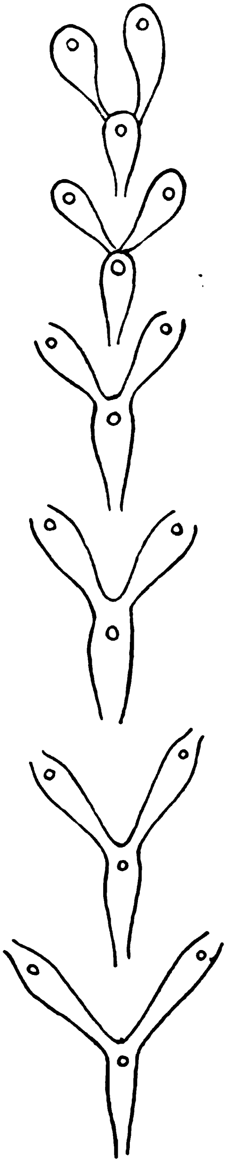
[3] G. R. Vine, "Polyzoa from the Cornbrash of Thrapston": Proc. Yorks Geol. & Polytech. Soc., vol. xii (1893), p. 252, pl. xii, fig. 4.

[4] G. R. Vine: loc. cit., p. 250, pl. xii, fig. 1.

[5] J. W. Gregory: Brit. Mus. Cat. Jur. Bry., 1896, p. 56, fig. 8, which is a reproduction of Gregory's figure in "The Jurassic Bryozoa of the York Museum" (Rep. Yorks Phil. Soc., 1893, p. 58, fig. 1).

[6] For the terminology employed see Lang, "Jurassic forms of the 'genera' *Stomatopora* and *Proboscina*": GEOL. MAG., 1904, p. 319.

The following diagram shows these forms and three others which complete the series in the Bathonian; and from it can be seen the changes accompanying the shape and length of the zoœcia in passing from the lower to the higher horizons:—



6. *Cellaria Smithi*, Phillips: Cornbrash, Scarborough, Yorkshire.

5. *Stomatopora Phillipsi*, Vine: Cornbrash, Thrapston, Northamptonshire.

4. *Stomatopora intermixta*, Vine: Cornbrash, Thrapston, Northamptonshire.

*3. *Alecto dichotoma*, Michelin: Bajocian, Calvados, Normandy. = *Alecto dichotomoides*, d'Orbigny.

2. *Stomatopora dichotomoides*, Haime: Aalenian, Pea Grit, Postlip. = *Stomatopora dichotomoides* (d'Orbigny), mutation *Murchisonensis*.

1. *Stomatopora Gregoryi*, mutation *capricornensis*, Lang: Lias, *capricornus* zone, Cherrington, Warwickshire.

EVOLUTION OF *STOMATOPORA DICHOTOMOIDES* (d'Orbigny).

distally. The shape of the zoœcia is slightly pyriform at first, becoming more so distally. Haime's figure makes them appear a little too pyriform. The zoœcia are very slightly ribbed throughout.

The actual measurements of two specimens of this form are given in the following table with those of the fragmentary zoœcia which represent the other forms. It will be seen that as far as can be

	Haime's type of *S. dichotomoides*: Aalenian, Postlip.	British Museum specimen B 2287 (8), 2 zoaria: Aalenian, Crickley.	Michelin's figure of *Alecto dichotoma*: Bajocian, Bayeux.	Vine's figure of *S. intermixta*: Cornbrash, Thrapston. ? $x = 2$.	Vine's figure of *S. Phillipsi*: Cornbrash, Thrapston. ? $x = 3$.	Gregory's figure of *S. Smithi*: Cornbrash, Scarborough. ? $x = 4$.
TYPE OF BRANCHING.						
At dichotomy 1	I. 180°	I. 180°	I. 180°			
„ „ 2	I. 120°	I. 120°–160°	I. 120°	I. 120°		
„ „ 3	I. 80°–90°	I. 90°–120°	I. 90°–120°	I. 120°	I. 80°	
„ „ 4	I. 60°–80°	I. 90°	I. 45°–60°	I. 60°	I. 80°	I. 60°
„ „ 5	I. 45°–50°	...	...	I. 90°		
„ „ 6	I. 45°–60°					
NUMBER OF PERISTOMES BETWEEN EACH DICHOTOMY.						
Before dichotomy 1 ...	?	? 2	2			
Between dichotomies 1 and 2	1	1–2	1			
„ „ 2 „ 3	1	1	1	1		
„ „ 3 „ 4	1	1	1–2	1	1	1–2
„ „ 4 „ 5	1–2	...	1–2	1	...	1–2
„ „ 5 „ 6	2					
RATIO OF LENGTH OF ZOŒCIUM TO BREADTH; BREADTH = 1.						
Before dichotomy 1 { Zoœcium 1	?	...	1½			
Before dichotomy 1 { „ 2	?	? 2	2			
At dichotomy 1	2½	2½–4	2			
„ „ 2	3	3–3½	2	2½		
„ „ 3	3	3–3½	2¼	2½	2½	
„ „ 4	3½	2½–3	2–2½	2	2½	2½
„ „ 5	3					
„ „ 6	3					
SHAPE OF ZOŒCIUM.	Rather pyriform.	Cylindrical or very slightly pyriform before 1. 1–2 slightly pyriform. 3–6 pyriform.	*Before 1.* 1. Cylindrical. 2. ? Slightly pyriform. *After 1.* Pyriform.	Pyriform.	Pyriform.	Hippothoiform.
ORNAMENTATION.	Very slightly ribbed throughout.	Very slightly ribbed throughout.	?	Slightly ribbed.	?	?

determined the only changes throughout the series are in the shape of the zooecia, which pass from slightly pyriform to hippothoiform, accompanied by a change in length from more than 2½ to less than 2½.

It is probable that the more primitive forms of this series persisted into and through Bathonian times, and were the ancestors of at least the primitive forms of the Middle Oolites. So that the direct line of descent would not pass through *S. Smithi* (Phillips), but rather this specialised form is the end of a side branch which includes *S. Phillipsi* (Vine) and *S. intermixta* (Vine). The line of forms represented in the diagram should in this case bend aside in the middle. But Bathonian forms as primitive as *S. dichotomoides* (d'Orbigny) have yet to be discovered.

VII.—SOME CLAY BEDS BY THE OUSE.

By BEEBY THOMPSON, F.G.S., F.C.S.

IN the maps of the Geological Survey, Quarter-sheet No. 52, S.W. (Bedford), published in 1863, Upper Lias Clay is shown as bordering the Ouse Valley between Stoke Goldington and Olney, directly overlaid by the Great Oolite, that is to say, the maps indicate an entire absence of the Inferior Oolite (Northampton Sand).

The only exposure of the clay I have seen is at Stoke Goldington brickyard, and until a few weeks back the only fossils I could find there were a few belemnites, but from these belemnites and the general appearance of the clay I felt quite satisfied as to its being Upper Lias.

In Mr. H. B. Woodward's "Jurassic Rocks of Britain," vol. iii, p. 277, occurs the following passage: "Inlying exposures of Upper Lias have been mapped at Stoke Goldington and Weston Underwood, between Olney and Newport Pagnell. I have examined the exposures in company with Mr. A. C. G. Cameron, and we found no evidence of Upper Lias. The clays exhibit green and purple tints, like the Upper Estuarine Beds, with which I think they should be grouped. The occurrence of 'Nail-head spar' in the clay at Stoke Goldington brickyard might be taken as suggestive of Upper Lias; but bands of fibrous carbonate of lime, or 'beef,' are not uncommon in the Upper Estuarine Beds, and the 'cone-in-cone' structure of the nail-head spar seems to be intimately connected with the 'beef.' It is, however, not unlikely that in this neighbourhood, as further westward, the Estuarine clays may, in places, rest directly on Upper Lias Clay, for the Northampton Sands become much attenuated, and may not always be present." A similar description of the same beds occurs at pp. 393–4 of Mr. H. B. Woodward's "Jurassic Rocks of Britain," vol. iv.

Knowing what a very careful stratigraphical geologist my friend Mr. H. B. Woodward is, I felt inclined to drop my own opinion, which I could not satisfactorily confirm, and accept his, for which better evidence seemed to be offered, but being in the neighbourhood in August last with Master Gerard Thornton, an enthusiastic young geologist with a keen eye, I thought it would be a good opportunity to make a gallant attempt to solve the problem of the clay beds at

Stoke Goldington. The attack was a short one, and the victory complete for the Upper Lias theory. Below is the section then made :—

Section at Stoke Goldington Brickyard (August, 1906).

	ft.	in.
1. Soil ... ... 2 feet to	3	0
2. River Gravel. A gravel almost exactly like that to be found at several other places between here and Olney, containing chalk, flint, Bunter pebbles, Great Oolite limestone, etc.	4	0
In one part of the section only there is a kind of junction clay containing fragments of *Ostrea*, and therefore probably Oolitic in origin, though not necessarily so. Thickness not more than about 6 inches.		
3. Upper Lias Clay. Good typical material, not variegated, not bleached, not disturbed. Containing some iron pyrites in thin slabs, also larger pieces up to 2 or 3 lbs. in weight. The iron pyrites is not obtrusive in the clay, either as lumps or by discoloration	8	0

Fossils found :—

Ichthyosaurus (vertebra).
Ammonites fibulatus (singly and in bunches).
Ammonites of the *subplanatus* group? (fragments).
Belemnites and phragmocones (fragmentary).
Cerithium costellatum, Munst. (part only, but that good).

The clay has been proved to be the same for a further depth of 10 feet by means of a well (or sump), so that a uniform clay extends for a depth of at least 18 feet below the river gravel. The fossils recorded above came from below the 8 feet now exposed, say from a depth of 10 feet at least; and considered in conjunction with the rareness of all fossils, they indicate the upper part of the 'Unfossiliferous' beds a little below the '*Cerithium*' beds or 'Lower *Leda-ovum*' beds of Northamptonshire,[1] *Cerithium costellatum* being one of the forms nearly always found associated with the abundant *Cerithium armatum*. Mr. Woodward's record of 'Nail-head spar' fits in admirably with the horizon suggested.

In my own cabinets the fossils from the unfossiliferous beds (of Judd) are labelled "Fibulatus" zone, not that *Ammonites fibulatus* is confined to the zone; indeed, the best specimens I have come from the *Leda-ovum* beds of the south-western parts of Northamptonshire,[2] but because for some 70 feet of Upper Lias, at least in Northamptonshire, it is the only ammonite that one is pretty certain to find traces of, and if it is found where all other fossils are very rare the zone is identified, but near the bottom and near the top of the zone other fossils are not quite so rare.

Some interesting problems are suggested by the occurrence of such comparatively low beds of the Upper Lias on the border of the Ouse Valley, such as—Are the upper beds of the Upper Lias missing? Does the Great Oolite rest directly on the Upper Lias? Is the Northampton Sand entirely absent, and if absent, why? etc. We will consider the evidence available on these points.

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[1] Beeby Thompson, "The Upper Lias of Northamptonshire," pt. vi: Journ. Northants Nat. Hist. Soc., vol. v (1888), p. 54.

[2] *Ammonites fibulatus* appears to continue into successively higher beds of the Upper Lias as we go in a south-westerly direction.

The top of the Lias Clay at Stoke Goldington is at about 188 feet above O.D.,[1] and this is certainly very near to the level of the top of the Lias Clay at two other sections to the eastward, within a mile or so, where river gravel is worked to a depth of 191 feet O.D., showing that in this particular area the top surface of the clay is determined by (comparatively) recent diluvial action, and that higher beds may be reasonably expected to occur near at hand where diluvial action has not been operative.

In the absence of exposures of rock at a higher level at Stoke Goldington the problem was treated in this way:—Going to the N.N.W., we find the base of the Great Oolite limestone at Piddington to be at about 300 feet O.D. At a point on the road between Horton and Stoke Goldington, about $2\frac{14}{16}$ miles from Piddington in a straight line, the probable base of the Great Oolite limestone is 260 feet O.D. A fall of 40 feet in the distance named means an average dip of 14 feet per mile along the line indicated; consequently at Stoke Goldington, $4\frac{1}{16}$ miles from Piddington, there should be a drop of 55 feet, making the natural base of the Great Oolite limestone there 245 feet O.D.

Again, at Ravenstone the base of the Great Oolite limestone appears to be about 250 feet O.D. (an investigation of several wells indicated this figure), and as the middle part of this village, where the Great Oolite source of water gives place to a gravel source, is $3\frac{11}{16}$ miles from Piddington in a direct line, this also gives a dip of close to 14 feet per mile. Furthermore, at a point about $\frac{3}{4}$ mile south of Ravenstone, towards Ravenstone Mill, Great Oolite limestone may be seen in an old quarry as low as about 240 feet O.D., which comes to nearly the same figure, viz., 14 feet per mile dip in a southerly direction. This last section is about one mile from Stoke Goldington brickyard, and as they are N.E. and S.W. of each other respectively, and the dip is distinctly greater south-eastward than southward, it appears highly probable that the former estimate for the natural position of the base of the Great Oolite limestone at Stoke Goldington is about correct, viz. 245 feet O.D. This naturally leaves $245-188 = 57$ feet to be filled up; the only question is what with?

As there is no recognisable Northampton Sand, either ironstone or Lower Estuarine sands, in the area under review, the disposition of the 57 feet is left with the Upper Estuarine beds and the upper beds of the Upper Lias.

Near to Olney, half a mile north of the railway station, and a little over 4 miles north-east of Stoke Goldington, a well was sunk through 27 feet of Upper Estuarine beds,[2] and as this is a very good thickness for the beds in question, and yet not greatly different from the thickness of the same beds at Roade cutting (24 feet 10 inches), a little over 6 miles to the north-west of Stoke, we may fairly well accept it as the local thickness, and if we do it leaves 30 feet to be made up with Upper Lias at Stoke Goldington.

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[1] All levels were taken with a Watkin aneroid barometer on a moderately satisfactory day for such work, but of course require revision for strict accuracy.

[2] H. B. Woodward: "Jurassic Rocks of Britain," vol. iv, p. 394.

Next let us consider the beds near to Olney. The greater part of the town of Olney is supplied with water by shallow wells in the Ouse Valley gravel, but in the southern part of the town, between the Market Place and the river, and south-westward, on the road to Weston Underwood, the wells are from 60 to 80 feet deep in Lias Clay. It has been assumed that the difference in depth is due to an unconformity between the Upper Lias and the Upper Estuarine beds.[1] Personally I can see no reason whatever for this assumption, for no surface irregularity in the upper beds, not relied upon for water, could possibly alter the level above ordnance datum at which water is found. Wells are not all started at the same level, and if they were some might have a deeper sump than others. However, here is some evidence bearing upon this question of unconformity and other points.

At the extreme south-eastern end of Olney, and on the south side of the road, there used to be a brickyard (the excavation can still be seen). Mr. Cameron reports[2] that the beds worked were yellow and blue clay, and that there was a sand bed one foot thick at the depth of 8 feet from the surface. It is suggested that this sand bed may perhaps be a representative of the Northampton Beds (see remarks later).

Not many yards eastward of this disused brickyard a well has been made for the supply of some cottages, and the report given to me of this well was that it was 80 feet deep, all in blue clay, and that they got water from a black rock 2 feet thick, below which blue clay was again met with; the water rose 50 feet from the rock.

A little westward of the old brickyard, just about where the hill begins to rise sharply, a small excavation made in levelling for a hayrick exposes about 3 feet of a light-coloured oyster marl. Seven feet below the top of this, water flows from the bank.

The levels hereabouts are as follows:—

	Above O.D.
Water-level in the river	163 feet.
Level of spring from marl (base of Upper Estuarine beds ?) ...	182 ,,
Well-top at houses	187 ,,
Top of clay at old brickyard ... ... certainly near to	182 ,,

Further along the very steep cliff bordering the Ouse Valley between Olney and Weston Underwood, limestone or marl was found at various places between the levels of 211 feet O.D. and 229 feet O.D. So far as it goes this is satisfactory, for without correction it would mean Upper Estuarine beds not more than $211 - 182 = 29$ feet thick and Great Oolite limestone not less than 18 feet. The highest exposure of limestone coincided with the fence, but the roadway is six feet higher, and obviously at least this amount must be added to the limestone, making it 24 feet, so that not much need be added to it below.

If we consider that the base of the Upper Estuarine beds at Stoke Goldington is correctly indicated by the level $245 - 27 = 218$ feet O.D., and at Olney by 182 feet O.D., then there is a dip from the former locality to the latter of 36 feet, or 9½ feet per mile, and this same dip would take the horizon of the Lias beds exposed at Stoke Goldington to a level of 188 − 36 = 152 feet O.D., which is 11 feet below river level, so obviously any sections of Upper Lias exposed between Stoke Goldington and Olney would consist of higher and higher beds as one approached the latter place, and this may easily in part account for Mr. Woodward's description of the clay beds in this area not agreeing with my own, though of course he also saw some Upper Estuarine exposures.

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[1] Ibid.

[2] Ibid., p. 394.

I quite believe that the uppermost clay beds towards Olney, here described as Upper Lias, may well represent, in time, the Northampton Sand, as I have previously suggested that the highly pyritous clays do at Grafton Regis, some few miles to the west.[1]

No unconformity between the Lias and Oolites in the area under consideration has been actually detected, and with the above explanations one is not needed; moreover, it would be somewhat difficult to account for if it occurred in an area which was sinking throughout the later Liassic and the whole of the remainder of the Jurassic period; as is evidenced by the formations which are absent as well as those present in districts further to the south and south-east, indicated by the deep borings, etc.

VIII.—ON SOME FOSSILIFEROUS KEUPER ROCKS AT BROMSGROVE (WORCESTERSHIRE).

By L. J. WILLS, B.A., King's College, Cambridge.

THE counties of Warwick and Worcester have yielded the majority of Keuper fossils recorded from England. The history of their discovery commenced about seventy years ago with a paper by Murchison and Strickland,[2] where there is a description of the area. They distinguished two divisions, the lower of which they identified as Bunter, chiefly on the evidence of a plant, *Echinostachys oblongus*, Brongn. This division was found to be, for the most part, composed of sandstones, and contained in Worcestershire plant remains and in Warwickshire bones and teeth. The localities where fossils were found were Ombersley, Hadley, Elmley Lovett, all on the west side of the Droitwich basin, Bromsgrove on the east of it, and in the Warwick district.

Their upper division was composed of marls with intercalated sandstones in some places. This they referred to the Keuper. They held that the sandstones of Burge Hill, Pendock, Inkberrow, and Shrewley, although very scattered, represented a definite horizon in the marls. They recorded fossils from these localities.

Professor Hull,[3] in 1869, corrected the nomenclature and recognised an unconformity between the true Bunter and Keuper in England in the place of the Muschelkalk. His divisions of the Lower Keuper (Murchison and Strickland's Bunter) are:—

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[1] "Junction Beds of the Upper Lias and Inferior Oolite in Northamptonshire": Journ. Northants Nat. Hist. Soc., vol. xii (No. 94, June, 1903), pp. 68–69.

[2] Murchison & Strickland: Trans. Geol. Soc., ser. II, vol. v (1837), p. 331.

[3] E. Hull, "Permian and Triassic Rocks of the Midlands": Mem. Geol. Surv., 1869.

1. **Waterstones:** micaceous laminated sandstones and beds of marl.
2. **Building-stone:** thick non-micaceous sandstones.
3. **Basement beds:** sandstones, conglomerates, and calcareous sandstones.

Although Hull dealt with the whole of the Midland counties, he noticed no plants from the Lower Keuper except those from Worcestershire, which had been described by Murchison and Strickland, and none of the newer Survey Memoirs has supplied any further records. His memoir contains a valuable list of fossils, to which only a few have since been added.

With the exception of Owen's[1] and of Miall's[2] descriptions of the Labyrinthodont remains in the Warwick Museum, and of Huxley's note on *Hyperodapedon*[3] and a few other descriptive papers, including those in the recent British Association Reports,[4] nothing has since been written about the Lower Keuper of these counties.

I purpose, at present, to deal more especially with the Lower Keuper of Bromsgrove. But since the beds here are rich in plant remains, it may be of interest to note those plants that have been recorded from the Upper Keuper. In 1855 W. S. Symonds[5] described the Pendock Beds, and mentions plants which were identified as belonging to either *Calamites arenaceus* or *Equisetites columnaris*, but which were more probably *Equisetites arenaceus*. In the following year J. Plant[6] noticed *Equisetum* from Leicester, while vegetable remains, including "*Voltzia* in fructification," *Calamites*, and *Carpolithes*, were recorded by P. B. Brodie from Shrewley and Rowington,[7] to which J. Phillips added *Walchia hypnoides*.[8] Their specimens, in so far as they still exist, are in too poor a state of preservation to allow of re-identification. I have added one new locality, south-east of Green Lane Farm, Callow Hill, in Worcestershire, where indeterminable plant remains have been found associated with *Estheria*. The above records point to the scarcity of the flora and illustrate the doubtful nature of many of these identifications.

The beds at Bromsgrove in which I have found fossils are the Waterstones and upper part of the Building Stone of Hull's classification, which are extensively quarried on the hill about a mile to the south-west of Bromsgrove, known as Rock Hill and Hill Top. The four quarries belong alternately from south to north to Mr. Willcox and Mr. Griffin, to both of whom I am much indebted for assistance. The beds show alternations of sandstone and shales, and a band of marl conglomerate, the whole dipping at a low angle to the south. The shales thicken and thin out in a most extraordinary way, which makes any measurements and comparisons of the beds in the various quarries practically impossible. This variation is quite in keeping with the false bedding seen throughout in the sandstones. (See Fig. 1.)

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[1] R. Owen: Trans. Geol. Soc., ser. II, vol. vi (1842), p. 503; and Palæontology, 2nd ed. (Edinburgh, 1861), p. 278.

[2] L. C. Miall: Q.J.G.S., vol. xxx (1874), p. 417.

[3] T. H. Huxley: Q.J.G.S., vol. xxv (1869), p. 138.

[4] Reports of Trias Committee of British Association, 1903, 1904, 1905, 1906.

[5] W. S. Symonds: Q.J.G.S., vol. xi (1855), p. 450.

[6] J. Plant: Q.J.G.S., vol. xii (1856), p. 373.

[7] P. B. Brodie: Q.J.G.S., vol. xii (1856), p. 374; vol. xliii (1887), p. 540; vol. xlix (1893), p. 171.

[8] J. Phillips: "Geology of Oxford and Thames Valley," p. 97; Oxford, 1871.

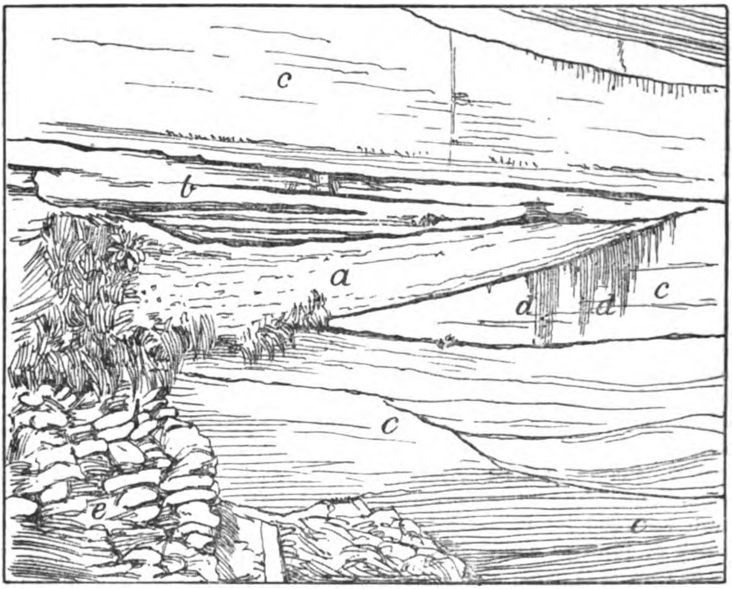

FIG. 1.—Section seen in Mr. Griffin's quarry.

a. Bed of marl.
b. Sandy shales.
c. Thick-bedded but cross-grained sandstone.
d. Stains showing how the water comes out at base of marl bed.
e. Part of tip heap, blocks of sandy shale.

These are fine-grained, micaceous, red, and often flaggy at the top, and grey at the base. The topmost beds are only seen in Mr. Willcox's south quarry. In the lower series no large beds of shale are present. Plant remains occur practically throughout; if in the red stone, they bleach it to a grey, or more often yellow colour. By this characteristic I have been able to detect similar plant remains in the sandstone surrounding the Droitwich basin at Belbroughton, Northfield, and the Tack Quarry at Hewell, as well as at the localities recorded by Murchison and Strickland. The sandstones often contain pebbles of marl, some of which, on fracture, occasionally show beautiful crystals of calcite, which also occurs commonly within the plant stems. Another curious mineral is green copper carbonate, which I have found both in the stems and as impregnations in the sandstone. These occurrences are comparable with that of the copper ores of Alderley Edge in Cheshire,[1] and possibly of Mansfeld[2] in the Hartz. At certain horizons the plants are found in well-marked carbonaceous layers. In some places in the sandstone are quite gigantic stems, one, for instance, being about 7 inches across and several feet long. I believe that the marl conglomerate, which usually contains fragments of bone, represents a definite horizon in all four quarries, but I have failed to locate its position in Mr. Griffin's north quarry, although it occurs there. If so, this is the only constant bed. It is curious that at Warwick most of the bones came from a very similar marly conglomerate; at Pendock, Symonds calls the fossiliferous bed an osseous conglomerate; and at Shrewley, Brodie mentions a conglomerate which also contains fish and Labyrinthodont remains. Small ripple-marks have been found in the sandstone in Mr. Willcox's north quarry. The false bedding points towards rapid sedimentation, and this is supported by the fact that leaves of *Zamites*, 6 inches long, have been found lying at right angles to the general direction of the bedding, and also doubled on themselves with a good thickness of matrix between the two parts. The sandstones, especially in their upper part, are intercalated with shale beds, and the following sections along the dip faces in two quarries 150 yards apart show the inconstancy of the beds very typically. (Fig. 2.)

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[1] E. Hull: op. cit., pp. 54, 65, and 74.
[2] J. A. Phillips: "Ore Deposits," p. 28; London, 1884.

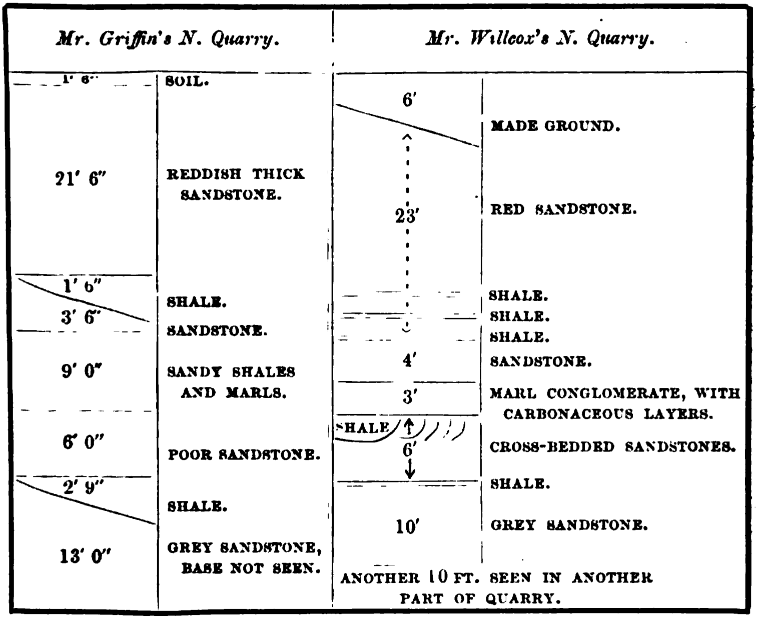

FIG. 2.

The sandstones are for the most part quite different in texture, and especially in bedding, from those of the Upper Keuper which I have, so far, seen at Inkberrow, Shrewley, and Leicester.

The shales, which occur really as flat-topped lenticles (see Fig. 1, *a*, *b*), are of various hues from brown to green. The majority are sandy, but some are true marls, and break up into very fine fragments by rudely spheroidal weathering. The brown shales are well seen in Mr. Griffin's north quarry, where the 9 foot bed shown in the section has yielded good fossils, especially leaves of *Zamites*, which occur usually where the sediment changes from the sandy to the marly facies. These shales also show the same evidence of quick or even torrential sedimentation. The green ones are mostly sandy, and are best seen at the base of Mr. Griffin's south quarry, where they contain patches, absolutely black with vegetable matter, and quite free from sand. These sandy green shales are often minutely rippled, and apart from the black patches contain many fragments of plants and ? Arachnida. In Mr. Willcox's south quarry there are some red shales which have so far proved barren.

As regards the fossils, the most characteristic feature is the abundance of plants and Arachnidan remains. The latter are fragmentary. Murchison and Strickland[1] recorded from the Lower Keuper of Worcestershire—

Echinostachys oblongus, Brongn.
Part of a flabelliform palm-leaf.
Broad leaf of some Monocotyledonous plant.
Many narrow Monocotyledonous leaves resembling grasses.
Moulds of stems of doubtful character.

Mr. E. A. Newell Arber, who has very kindly assisted me by determining the plants, has examined their specimen of *Echinostachys* preserved at the Museum of the Geological Society, and regards it as a male cone of *Voltzia*. These were the only plants known from this horizon.

The following is a list of the fossils I have found, divided into those preserved in—

(i) *The Sandstone.*

Plantæ.
  Equisetites arenaceus (Jaeger): pith-casts and leaves.
  Zamites Vogesiacus (Schimper & Mougeot): leaves.
  Voltzia sp.: external surface of stem, male cone, and pith-casts of stems.
  Coniferous wood.
Pisces.
  Spine of *Acrodus*.
  Coprolite.
Amphibia.
  Teeth[2]; cranial, vertebral, and other bones of a Labyrinthodon (*Mastodonsaurus*)?
Reptilia.
  Hyperodapedon Gordoni.[3]

(ii) *The Shales.*

Plantæ.
  Equisetites arenaceus (Jaeger): pith-casts.
  Equisetites sp.
  ? *Chiropteris digitata*, Brongn.
  ? *Pterophyllum* sp.
  Zamites Vogesiacus (Schimper & Mougeot): leaves.
  Voltzia sp.: pith-casts of stem and male cones.
  Conites sp.
Arthropoda.
  Estheria minuta.
  Many fragments of ?Arachnida.[4]
Pisces.
  Dipteronotus cyphus.
  Scales.

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[1] Op. cit., p. 340.

[2] One of these is broken and shows very distinctly with a lens the characteristic structure.

[3] Part of the palato-maxillary bone, with three rows of teeth.

[4] I have shown some of these to Dr. Bather, who thinks that they may probably be referred to the Arachnida.

It will be seen from the above list that the fossils of the sandstone and of the shales are rather distinct, and that the fauna of the former recalls the vertebrates found at Warwick. The Labyrinthodont remains, next to the plants, are the most abundant fossils, but are apparently confined to the marl conglomerate.

The shale fossils, on the other hand, are better preserved, and show a great predominance of vegetable remains, but, in places, fragments of Arthropods are abundant. This is especially so in the above-mentioned black patches.

Of the Arthropods, the *Estheriæ* are very small, and quite different from the Upper Keuper type, so abundant at Shrewley. They resemble much more closely those that occur in the Rhætic, but I have not been able to determine whether they agree with the variety called *Brodiana.*[1] There is but one record of *Estheria* from the Lower Keuper of England, viz. at Alderley Edge.[2]

I have, so far, been able to find nothing comparable at all with the other Arthropod remains. There are pieces which are certainly segments of a jointed abdomen, and others which may represent carapaces. Dr. Bather thinks that some of the fragments may have belonged to a Scorpion, and some have a Merostomatous appearance.

Dr. Smith Woodward has kindly examined the only nearly perfect fish found, and refers it to *Dipteronotus cyphus*, Egerton, which has only once before been described, and that from near Bromsgrove.[3]

As regards the plants, the leaves of *Zamites Vogesiacus* are the most characteristic fossils. They are very abundant in the 9 foot shale bed in Mr. Griffin's north quarry. They are broad and lanceolate, with parallel nervation, average some 18 inches or more in length, and show the apex, and the base which has a well-marked callosity.

The pith-casts of *Equisetites* are abundant in the sandstone, but are fragmentary. There is a marked paucity of specimens showing the external surface and leaves.

The male cones of *Voltzia* are especially well preserved. Some show the complete cone with a basal stalk, both the external surface and also the internal structure being displayed.

It is because the Keuper plants hitherto described from England are so poorly preserved, and hence so dubiously identified, that the occurrence of even these few species at Bromsgrove in good preservation and some abundance is of especial interest. The abundance of Cycads and Equisetites points to a flora markedly Mesozoic, while the whole assemblage of fossils is that of the Lettenkohl (Lower Keuper) of South Germany, although some of the plants recall those of the Bunter of the Vosges,[4] while other species range up into the Schilfsandstein (Middle Keuper).

I have good hopes of adding to the above list by continuing my visits to these quarries, and by working out more completely the material recently accumulated; but since particular attention has of late been drawn to the Trias by a committee of the British Association, this preliminary sketch of the results already obtained may be of some service.

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[1] R. Jones, "Fossil Estheria": Pal. Soc., 1862.

[2] Rep. Brit. Assoc., 1905, where also compare the description of 'Vleys' with the marl beds of Bromsgrove.

[3] P. Egerton: Q.J.G.S., vol. x (1854), p. 367.

[4] Schimper & Mougeot: "Plantes fossiles du Grès bigarré," 1840.

My thanks are due to many friends, but especially to the quarry owners for very active help, to Mr. Arber for the identification of Triassic plants of which very little is known in this country, and to Dr. Smith Woodward for examining the vertebrate remains.

IX.—NOTES ON SOME RECENT WORK ON THE BOKKEVELD FOSSILS.

By F. R. COWPER REED, M.A., F.G.S.

IN a recent important article in the "Records of the Albany Museum, South Africa," vol. i, No. vi (1906), pp. 347–404, pls. vi–x, Professor Schwarz describes some interesting fresh material from the Bokkeveld Beds, and is able to add several new species to the steadily growing list. Incidentally he is led to criticise some previous work done by me on the Brachiopoda and Mollusca from the same beds. Whilst I welcome the new light he is able to throw on several of the obscure fossils with which I had to deal, I must demur to some of his conclusions, especially in the case of the Brachiopoda; and accordingly, as my opinion on his paper has been specially asked by other workers on this fauna, a few remarks appear to be requisite. It must not be forgotten that the specimens in all cases are poor and unsatisfactory, but Professor Schwarz has had the advantage over me of more abundant material.

1. With regard to his new species *Rensselæria relicta* (op. cit., p. 364, pl. vii, fig. 7), it is considered by Professor Schwarz to be perhaps identical with my *Rensselæria* sp. *a* (Ann. S. Afr. Mus., vol. iv, pt. 3, p. 176, pl. xxi, fig. 8). Without seeing his type it is naturally impossible for me to form a definite opinion, but his view seems to possess much probability, though my doubts as to the generic position of this shell have been recently expressed in my description of *Scaphiocœlia* (?) *africana* (GEOL. MAG., Dec. V, Vol. III (1906), p. 308). Better material will probably remove the existing uncertainty as to its specific and generic relations.

2. The ribbing in *Rensselæria hottentot*, Schwarz (op. cit., p. 365, pl. vii, fig. 8), as described and figured, does not suggest the genus *Rensselæria*, but rather the genus *Rhynchospira*, and the same remark applies to his *Trigeria simplex* (pl. vii, fig. 9), which I cannot agree is probably identical with my *Trigeria* aff. *Gaudryi*; the central grooved narrow fold or wide rib on the brachial valve, represented in Professor Schwarz's figures and mentioned in his descriptions, seems to forbid their reference to *Rensselæria* or *Trigeria*; and, as he remarks, *T. simplex* may rather be compared with Hartt's *Retzia jamesiana*. In placing the latter in the genus *Rhynchospira* I am merely adopting Clarke's view in the case of the Para examples, for the species has also been referred to *Notothyris* and *Centronella*.

3. Professor Schwarz arrives at somewhat different conclusions with regard to the specific separation of the members of the genus *Spirifer*, but he acknowledges the difficulties with which one has to

contend owing to the fossils occurring only as casts or impressions, and frequently in an imperfect condition. In the first place it cannot be denied that all the species described from these beds are closely allied, and that many intermediate forms occur which might be referred to one or other of the species with equal justice. Only the most marked forms at the extremity of each series of variations are in reality capable of precise definition, and it is by them that the specific characters have been established. Therefore the reference of many of the transitional examples and debatable specimens depends largely on the personal equation. In my case it should be remembered that I had the advantage over Professor Schwarz of examining the type-specimens in London. Professor Schwarz would restrict the name *Sp. Orbignyi*, Morris & Sharpe, to those forms possessing a more semicircular shape and a less incurved beak and more backward sloping hinge-area on the pedicle valve than *Sp. antarcticus*, Morris & Sharpe. To the transversely fusiform shells with nearly a vertical hinge-area and rather strongly incurved beak in the pedicle valve, which I included under the name *Sp Orbignyi*, Professor Schwarz applies the name *antarcticus*, Morris & Sharpe. In spite of the differences pointed out, and in view of further specimens which I have seen, I am reluctant to adopt his view, for the characters on which he relies do not seem to be constant.

My *Sp.* cf. *pedroanus* Professor Schwarz would include in his *Sp. antarcticus* (= *Sp. Orbignyi*, mihi), but with this view I cannot completely concur, for there appear to be special features in the number, character, and relative size of the ribs which I have previously mentioned (Ann. S. Afr. Mus., loc. cit., p. 183, pl. xxii, fig. 5). Professor Schwarz also misunderstands my description by thinking that I took *Sp. pedroanus* to have only 10–16 ribs in all, but the fact that I largely rely for the comparison on the number of the ribs (20–22) in the South African form should have been sufficient to indicate that I had clearly in my mind Hartt's statement that there were 10–16 ribs *on each side* of the fold and sinus. I am, however, ready to admit that my *Sp.* cf. *pedroanus* may not be identical with the South American species bearing this name, and may be only an extreme variety of the *Sp. antarcticus* of Professor Schwarz.

In the case of *Sp. Ceres*, mihi, Professor Schwarz believes that one of the specimens figured by me (pl. xxii, fig. 6) is an overgrown example of *Sp. Orbignyi* or *Sp. antarcticus*, though his very reasons for adopting this view considerably weaken his arguments in favour of the separation of *Sp. Orbignyi* from *Sp. antarcticus*. Likewise his inclination to identify *Sp. Ceres* with *Sp. Hawkinsi* (for which I cannot see sufficient evidence) proves that he allows much latitude of variation in his specific interpretations.

It is always a misfortune to have to multiply specific names, particularly in connection with poorly preserved fossils, and one would be glad to reduce the number of species of *Spirifer* recorded from the Bokkeveld Beds. But when local varieties or zonal mutations may be suspected it is wise not to neglect minor differences observable in specimens from other localities and rocks than the type; and particularly does this seem to be a necessary warning in the case of the Bokkeveld Beds with their diverse lithological development, and in view of the absence of minute zonal work or zonal collecting from the beds included in this stratigraphical series.

4. In the case of the Mollusca Professor Schwarz is able to record several new species. Perhaps with regard to the specimen identified as *Cypricardella Pohli*, Clarke, the figure leaves something to be desired, as, comparing it with the one given by Clarke of this species, there does not seem to be much resemblance. However, without seeing the specimen a fair criticism cannot be passed.

5. With regard to the trilobites and the points of difference between Professor Schwarz and Mr. Lake in their identification, it is not for me to pass any opinion. A small collection recently presented by the South African Museum to Cambridge includes a good example of the new species *Homalonotus hippocampus*, Schwarz, which, as the author states, is sharply separable from *H. Herscheli*. I notice the subgeneric name *Cryphæus* still used by Prof. Schwarz in connection with *Phacops*, though it has been shown to be preoccupied (Geol. Mag., Dec. V, Vol. II, 1905, p. 173), and it is doubtful if any of the South African forms referred to this subgeneric group, *Asteropyge*, can be rightly retained in it without undue extension of its meaning.

In a subsequent article a review of the whole fauna will be given.

NOTICES OF MEMOIRS.

I.—A Contribution to our Knowledge of the Limestone Knolls of Craven. By A. Wilmore, F.G.S.[1]

THE Craven Lowlands district, between the great faults on the north-east and the grit hills of the Pendle Range on the south, is characterised by a well-known series of limestone knolls which have been the subject of much discussion.[2] Having worked in the district for some years I venture to make the following suggestions.

I. The words 'knoll' and 'reef-knoll' seem to be differently understood by different workers. It seems to me desirable to drop the term 'reef-knoll.' This term was applied by Mr. Tiddeman to certain extreme members of a series: there is every possible gradation between these and ordinary rounded knolls to which the term would never be applied. Further, the hills so named by Mr. Tiddemán have not all originated in the same way.

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[1] Paper read in Section C (Geology) at British Association Meeting, York, 1906.

[2] Tiddeman: Brit. Assoc. Rep., 1899; Brit. Assoc. Handbook for Leeds and Airedale, 1890; Brit. Assoc. Rep., 1900; Geol. Mag., January, 1901. Marr: Q.J.G.S., vol. lv, pt. 3 (August, 1899); also Dakyns in same number. W. Hind & Howe, "On the Pendleside Group at Pendle Hill, etc.": Q.J.G.S., vol. lvii, pt. 3 (August, 1901). Sir A. Geikie: "Text Book," vol. ii (1903), p. 1041.

II. The following types of knolls may be recognised:—

(A) Those in the grey or bluish-white limestone. Some of these are well-bedded and very fossiliferous; some are obscurely bedded; some are not *apparently* very fossiliferous.

(B) Those in the dark limestones with numerous shales: these knolls are lower and more rounded.

(C) Scar-knolls; truncated folds weathered into semi-rounded and more or less detached masses. These vary from small crags through large peninsular masses to long scar-like ridges. These may be in the white or dark limestones. Sometimes a scar-knoll has been detached from the main mass of a limestone by weathering.

There are gradations of every degree connecting these types.

III. Examples of all these types of knolls occur on one well-defined horizon. They may all be seen striking parallel with the Pendleside shales containing *Posidonomya Becheri*, *Posidoniella lævis*, *Aviculopecten papyraceus*, and immediately succeeded by these shales. The succession may be seen at Cracoe and Thorpe, Stockdale, Newsholme, Broughton and Thornton, Downham, Slaidburn.

IV. The knolls are most conspicuous on the margins of the district. They are seen close to the faults at Threshfield, Malham, Attermire, Stockdale, and Bell Busk. Against the grit ridges on the southern side they are well developed at Thorpe and Cracoe, Broughton and Thornton, and near Downham.

It is noteworthy that knoll-like masses are seen *north* of the Grassington branch of the Craven faults, at Craven Moor, and near Dibble's Bridge. Here the massive white limestones come up with a much greater dip than is usual north of the faults.

The whole district is much folded. There are well-defined folds with N.E.-S.W. axes intersected by less conspicuous folds parallel to the main Pennine axis. The interference of these fold-systems seems to have directly produced some of the knolls. Folding is seen everywhere, in both the dark and the white limestones; though the well-bedded dark limestones naturally show it best. Minor faults are common, and some of the knolls appear to be due in part to faulting.

V. The more massive knolls of white limestone appear to be due to irregular aggregations of submarine débris. Folding has ridged up these massive limestones, and weathering has intensified the difference between these and the commoner knolls of the district. The smaller knolls are due to folding (as in IV) and subsequent weathering.

II. — INVESTIGATION OF THE FOSSILIFEROUS DRIFT DEPOSITS AT KIRMINGTON, LINCOLNSHIRE, AND AT VARIOUS LOCALITIES IN THE EAST RIDING OF YORKSHIRE.[1] By J. W. STATHER, F.G.S.[2]

The Speeton Shell-bed.—As mentioned in last year's report, this fossiliferous estuarine sand was first described by Professor Phillips in his "Geology of Yorkshire" (pt. i, p. 100), and later by Mr. G. W. Lamplugh in the Geological Magazine for 1881 (p. 176). As the bed is almost always obscured by slips, so that its relations to the drift are open to question, it was decided to examine its position by excavations.

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[1] Report of the Committee, consisting of Mr. G. W. Lamplugh (Chairman), Mr. J. W. Stather (Secretary), Dr. Tempest Anderson, Professor J. W. Carr, Rev. W. Lower Carter, Mr. A. R. Dwerryhouse, Mr. F. W. Harmer, Mr. J. H. Howarth, Rev. W. Johnson, Professor P. F. Kendall, Mr. H. B. Muff, Mr. E. T. Newton, Mr. Clement Reid, and Mr. Thomas Sheppard.

[2] Paper read in Section C (Geology) at British Association Meeting, York, 1906.

Since the presentation of the last report several excavations have been made in the neighbourhood of the exposures seen by Professor Phillips and Mr. Lamplugh, and your Committee reports that, though the results obtained are corroborative of the accounts given by the observers above named, they also include certain new points of interest.

The largest excavation was made in the ridge between Middle Cliff and New Closes Cliff at Speeton, and at this place beds were exposed as follows:—

			ft.	in.
	(A)	Boulder-clay (lower part only excavated)	45	0
ESTUARINE SHELL-BED.	(B)	Fine chalky gravel	1	6
	(C)	Yellowish sandy silt with shells	6	2
	(D)	Black silt	4	0
	(E)	Black silt with sandy streaks and a little gravel	2	0
	(F)	Fine gravel, chiefly of chalk	4	0
	(G)	Speeton Clay (base of *Bel. jaculum* zone 1½ feet, and "compound nodular band" 6 inches, forming the upper portion of the sloping cliff of secondary clays 84 feet above beach-level).		

It will be seen from the above section that the shell-bed is here 17 feet 8 inches thick, and its base is about 86 feet above the present beach.

The gravel (F) rests on the *Bel. jaculum* clays, but contains some material washed from the lower beds of the Speeton Clay, such as fragments of *Bel. lateralis*, etc.

The excavation showed that the beds do not rest on a flat surface of Speeton Clay, but that their surface dips into the cliff at an angle of 25 degrees, and that the bedding of the shelly deposit itself also dips into the cliff at about the same angle.

Shells occur throughout the silty beds, but are most plentiful in bed C. When excavating, the shells seen were *Cardium edule*, *Tellina balthica*, *Scrobicularia piperata*, and *Hydrobia*. A quantity of the shelly material was collected for washing, on which the Committee will report later.

Search was made for the shell-bed at the same level both north and south of the main excavation. Southwards no trace was observable, but northwards the beds were traced fifty yards along the slopes of New Closes Cliff.

At the foot of the cliff, about 500 yards northward of the site of the excavations, similar shelly silts were laid bare during favourable conditions of the foreshore early this year. In this exposure the beds attained a thickness of 4 to 5 feet, and were traceable for at least 100 yards. The silts rested on Kimeridge Clay, and were overlain by glacial drifts, which at this locality are extremely thick.

At the north end of this section the following particulars were noted:—

	ft.	in.
Boulder-clay with intercalated stratified sand and gravel, not less than	120	0
Fine chalky gravel	2	0
Silt with shells	3	0
Kimeridge Clay	4	0

The thanks of the Committee are due to the Right Hon. the Earl of Londesborough for permission to investigate the shell-bed at Speeton, and to Mr. C. G. Danford, of Reighton, for help in many ways.

REVIEWS.

I.—MEMOIRS OF THE GEOLOGICAL SURVEY, ENGLAND AND WALES. EXPLANATION OF SHEET 110: THE GEOLOGY OF THE COUNTRY AROUND MACCLESFIELD, CONGLETON, CREWE, AND MIDDLEWICH. By T. I. POCOCK, M.A. With Contributions by G. BARROW, F.G.S., W. GIBSON, B.Sc., F.G.S., C. B. WEDD, B.A., F.G.S., and J. A. HOWE, B.Sc., F.G.S.; and Notes on Fossils by E. T. NEWTON, F.R.S.[1] pp. 138. 1906. Price 2*s*. 6*d*.

MAP. SHEET 110. 1 inch to the mile. An edition showing drift and solid. Printed in colours. Price 1*s*. 6*d*.

IN this new issue of Sheet 110 we have an excellent map at a low cost. The new method, adopted in the map of Stoke-on-Trent, immediately contiguous, supersedes the old hand-coloured maps, with their inaccuracies due to the personal vagaries of the colourist, the difficulty of getting the same tint of colour on different copies, and the want of permanence in the colour, due to fading, and to the fact that the colours run, if the map gets damp. The production of the map is one for hearty congratulations to all concerned, but we would fain have seen two editions, a drift and a solid.

The present edition attempts to show both, consequently the solid geology of the area is not as distinct as it might be. The sheet introduces more country to the west and less of the east than in the old edition, and on the whole takes in a much larger area. We are glad to see the term Pendleside Series adopted for the beds between the Carboniferous Limestone and the Millstone Grits, and a distinctive colour adopted for them. We hope that the Survey will continue the use of the term for similar beds on the eastern side of the Pennine uplift and thus avoid further ambiguity.

The map, we understand, is printed and coloured at the Ordnance Office, published by the Board of Agriculture, and distributed, as agent apparently, by Fisher Unwin.

The Memoir contains detailed descriptions of the various divisions of sedimentary rocks which occupy the area of the map. They include the small inlier of Carboniferous Limestone of Astbury with its volcanic tuff, an extensive development of the Pendleside Series and Millstone Grits, and the Coal-measures of the Biddulph Basin. East of the Red rock fault the whole area is occupied by Triassic rocks of the Bunter and Keuper divisions. The whole district is more or less overlain by glacial deposits, but the high ground on the eastern margin of the map is comparatively free from drift.

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[1] A brief note of this Memoir appeared under "Notices of Memoirs" in the December Number of the GEOLOGICAL MAGAZINE, 1906, p. 558.

In the last edition of the Memoir on this area there was a small sketch-map of the district geologically coloured. The absence of this we regret in the new edition; we should like to see such a map in every memoir issued by the Survey. It is most useful for reference by the student of the memoir. All work in the area by local geologists has been duly acknowledged, and we note that the palæontology is almost entirely due to local workers.

The area is an interesting one, and includes the western limb of the great Pennine anticlinal, and part of the Triassic plain which abuts against it. In the north-west corner of the map the surface of the land is 84 feet above O.D., while at Shutlingslow the top of the hill is 1,658 feet above O.D.

In the area included in the map the Millstone Grits are thinning out rapidly from north to south and from east to west. In the north-east five beds of Grit can be made out, but at Mow Cop only two of them, supposed to represent the first Grit or Rough rock and the third or Roaches Grit, are found, and these much less thickly bedded than to the north-east.

The area contains a very interesting patch of igneous rock well exposed in Astbury Old Limestone Quarry and the stream to the north. The north end of the quarry shows a large thick mass of agglomerate containing well-preserved fossils and blocks of marmorised limestone. In the southern part of the quarry beds of intrusive material, which have baked the shales above and below them, are to be seen intercalated in a shale and limestone series which forms the base of the Pendleside Series, and contain *Prolecanites compressus* and Trilobites and Corals belonging to *Amplexizaphrentis* and *Cyathaxonia*. We fail to find any account of this important fauna in the memoir.

The chapter on the Pendleside Series is of interest, and we congratulate the author that he has wisely seen fit to include a large amount of palæontology in this part of his memoir.

Eighteen pages are devoted to the Millstone Grit, and here, alas! we find no palæontological work, though the shales between the grits contain marine faunas. Twelve pages only are allowed for a description of the Coal-measures, and two-thirds of a page is all we have on fossils and fossiliferous horizons in that field. In the chapter on the Trias (p. 59) we meet with the following statement: "The district, however, affords evidence that this continental period (alluding to the Trias as 'this remarkable land period') slowly passed away, and was succeeded by one of regional depression, during which the Midlands and a large portion of England sank once more beneath the ocean." Taken in conjunction with this we find on p. 65: "The Jurassic deposits, which elsewhere conformably succeed the Trias, doubtless overspread the lower, if not the higher, parts of this area also; a large outlier still remains in the county of Shropshire. Nor is it likely that the north-western counties escaped the more general submergence of England which ensued in Cretaceous times." We take exception to these views and ask for the proofs or evidence.

Granted the continental conditions, or rather the inland salt sea, of Trias times, out of which the Lake Hills and the Higher Pennines above 800 feet appeared, what evidence is there that these areas were ever again submerged? The crevices and caverns of the Carboniferous Limestone contain no relics of Jurassic or Cretaceous age, as is the case in Somersetshire. No outliers of Secondary rocks are found in the Pennine area or the north-west counties of England, or occur nearly as high above sea-level as the highest Triassic beds of the Midlands. The large sand and clay pits of Staffordshire and Derbyshire contain nothing later than Triassic material and Glacial drift. One cavern in Derbyshire alone has yielded bones of Pliocene animals, but this fact does not bear on the question of a depression beneath the sea to over 2,000 feet in the Midlands. Consider the height above O.D. at which Jurassic deposits are found elsewhere, even the two nearest to the area, the Shropshire and Needwood forest outliers. They are both at a much lower level even than the highest Triassic beds. In connection with this subject it would have been of importance and interest if the authors of the memoir had discussed the limits above O.D. of the Trias of the district. There is a long and important section on Glacial and other superficial deposits. The area is classical and contains the highest bed of marine shells in England, 1,200 feet above sea-level.

The Memoir is a useful introduction to the geology of the area; the illustration and sections are helpful to the geological student, and give him a graphic view of the tectonic structure of the district.

W. H.

II.—SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM FOR 1905. pp. 209, with 4 plates and 3 text-illustrations. Price 1*s*.

THIS is somewhat late in issue, considering that the far more elaborate Report of the Transvaal Geological Survey for the same year reached us some weeks ago. The present work contains particulars of the field-work in Derbyshire and Nottinghamshire, in Cornwall, Carmarthenshire, and Pembrokeshire, in the North and West Highlands of Scotland, and around Glasgow and Airdrie. The Survey of Ireland was severed from that of Great Britain during the early part of the year, so there has not been much to record about it. Among notable contributions to this work are Mr. J. A. Howe's report on Road-stones; Dr. Flett's descriptions of Lewisian rocks; Mr. Barron's account of recent excavations in London; and Mr. H. A. Allen's Catalogue of Types and Figured Specimens of British Lamellibranchiata from the Oolites, preserved in the Museum of Practical Geology.

III.—E. W. BERRY. I.—A BRIEF SKETCH OF FOSSIL PLANTS. II.—THE FLORA OF THE CLIFFWOOD CLAYS. Annual Report, Geological Survey, New Jersey, for 1905, part ii, pp. 99–156, with 8 plates and 7 text-figures. Trenton, N.J., 1906.

IN this sketch of fossil plants Mr. Berry touches very briefly upon a number of points connected with the study of palæobotany, such as methods of preservation, early views regarding fossils, and leaf venation. Perhaps the most interesting sections are those devoted to generalized ancestral forms and the Recapitulation Theory. Mr. Berry speaks of certain mid-Cretaceous fossils, such as those referred to the genus *Sassafras*, known only as leaf-impressions, as being synthetic types, combining characters common to other genera. We agree with the author's remark that "it is hardly safe to draw too definite conclusions from the evidence of one set of organs, such as leaves." As illustrations of the truth of the Recapitulation Theory, which Mr. Berry applies in a whole-hearted manner to the Angiospermous leaf-impressions, fossils assigned to *Liriodendron* and *Myrica* are discussed, and the leaves of the earliest representatives of these genera are found to resemble the 'juvenile' foliage of seedlings of the living plant.

In this connection we may repeat a word of warning. It may be taken as a general rule, to which the exceptions are but few, that it is not safe, we might almost say not scientific, to refer a fossil Angiospermous plant to a living genus solely on the evidence of leaf-impressions; an axiom which is too often lost sight of by those who devote attention to the difficult study of such plant remains.

This bright and interesting sketch concludes with a brief review of the succession of geological floras, especially in the United States. Some of the statements made are now hardly accepted, as, for instance, the proof of the occurrence of "ferns (Filicales) and horsetail rushes (Equisetales)" in the Cambrian and Silurian rocks, the Dawsonian theory that the Hydropterideæ were vastly abundant in the Devonian period, which the author refers to in a guarded manner, and the view, now no longer tenable though current as recently as the publication of this sketch, that the Carboniferous and Permian Fern-like plants were largely referable to the family Marattiaceæ. The interesting diagram included to illustrate the distribution of plants in geological time, and what is known as to their phylogeny, leaves one with the impression that the author holds that, in many cases, plant life was more varied and abundant at the *end* of a geological period than at the *beginning*, a theory which it would be exceedingly difficult to prove.

The second paper contains a description of the Cretaceous flora of the Cliffwood Clays of New Jersey. The most interesting specimen figured is a new Fern-like plant, apparently in the fertile state, for which the new genus and species *Heterofilicites anceps* is proposed, but there appears to be some doubt as to whether the sporangia-like bodies are really fructifications.

Among the other leaf-impressions described and figured are new species referred to *Picea*, *Platanus*, *Liriodendron*, and *Sterculia*.

E. A. N. A.

IV.—A NEW GEOLOGICAL MAP OF IRELAND.

MESSRS. J. BARTHOLOMEW & CO. have just published a "Map showing the Surface Geology of Ireland, reduced chiefly from the Ordnance and Geological Surveys under the direction of Sir Archibald Geikie, D.Sc., LL.D., F.R.S., late Director-General of the Geological Survey." Scale, 10 miles to 1 inch. Price 6*s*.

The map is on the same scale as Sir A. Geikie's maps of England and Wales and Scotland, issued by the same publishers, and is executed with even greater attention to detail; in fact, where the covering of drift is absent, the amount of detail shown is wonderful. At the same time, from the point of view of those who are neither agriculturists nor glacialists, it is a great pity that the map has not been issued as a solid-geology map, like its English and Scotch companion maps. The explanation is as follows:—The map was printed at the suggestion of the Department of Agriculture for Ireland, whose original intention was to have two maps, one showing solid geology and the other drift geology. Subsequently, however, they decided to have only one map, and chose the drift map as best suited to their requirements. It is to be hoped that Sir A. Geikie and Messrs. Bartholomew may see their way to issuing, at the earliest possible date, a solid-geology map, as the geological structure of the country is very much obscured by the drift, although it should be mentioned that the boundaries of the underlying formations beneath the drift are given. To make them out, however, requires minute study, so that a far better general idea of the structure of the drift-covered country is obtainable from Professor Hull's map, in spite of its less detailed character.

B. HOBSON.

V.—THE BERNESE OBERLAND.

DAS BERNEROBERLAND UND NACHBARGEBIETE: EIN GEOLOGISCHER FÜHRER, von A. BALTZER. Mit 74 Figuren im Text, und einem Routenkärtchen. Sm. 8vo; pp. 348. Berlin: Gebrüder Borntraeger, 1906.

THIS little work is one (No. xi) of a series of illustrated geological guidebooks to various districts in Europe. They have all been prepared by thoroughly qualified writers, among whom are to be found such well-known names as those of E. W. Benecke and A. Tornquist.

The volume before us is devoted to that beautiful and much frequented part of Switzerland known as the Bernese Oberland, which will conjure up for many a reader the most delightful recollections of long rambles among its mountains and valleys. It is divided into a number of routes and branch routes, and under each of these the physical and geological features are described with as much detail as the limits of space will permit. Some of the illustrations are in outline, others are reproductions from photographs, the latter mostly provided with key-plates, the different classes of rocks being indicated by the usual methods. There are also two plates, slightly tinted, from drawings made by the author to illustrate the Aletsch laccolith.

The writer, mindful that his little book is to serve as a guide, gives careful directions from place to place, adding the distance to be traversed on each journey that the wayfarer may know what is before him. There is a small map at the beginning of the book (scale 1 : 1,000,000) marked with red and blue lines, indicating the main routes and their branches described in the text. Its area extends approximately from Basel (the starting-point for all the tours) in the north-west corner of the map to Leuk in the south-west, and from Winterthur in the north-east to Airolo in the south-east.

A. H. F.

VI.—Geological Survey of Western Australia. Bulletin No. 23: Third Report on the Geological Features and Mineral Resources of the Pilbara Goldfield. By A. Gibb Maitland, Government Geologist. 8vo; pp. 92, with 7 geological maps and 13 figures. (Perth, W.A., 1906.)

THIS report contains descriptions of those mining centres in the Pilbara Goldfield not referred to in Bulletins 15 and 20. It includes full details of the gold-mining centres of Tambourah, Western Shaw, North Shaw, and Just-in-time, together with the tin-fields of Wodgina and Cooglegong. It is fully illustrated with coloured geological and mining maps, which help greatly in elucidating the text. A general summary is also given of the geological features, mineral resources, and future prospects of the Pilbara Goldfield, drawn up by Mr. A. Gibb Maitland, mostly from personal investigations. The author was assisted in the field-work by Mr. H. W. B. Talbot.

The occurrence of sections reveals geological structures not met with in the more southerly districts, and these also throw much light upon problems connected with the geology of other goldfields.

The following table exhibits the succession of the rocks met with in the Pilbara Goldfield :—

Recent	Blown sand, alluvium of the river beds, and residual deposits.
Oakover Beds (age ?) ...	Sandstones, limestones, etc.
Nullagine Beds (age ?) ...	Sandstones, grits, conglomerates, and volcanic rocks. (Gold-bearing in places.)
Mosquito Creek Beds (age ?)...	Grits, shales, and fine conglomerates. (Gold-bearing in places.)
Warrawoona Beds (Archæan ?)	Metamorphic sedimentary rocks, quartzites, conglomerates, greenstone schists, and allied rocks. (Gold-bearing.)
Granite and gneiss	(Tin- and tantalite-bearing and auriferous in places.)
Dolerite, Diabase, and Gabbro Dykes.	

The granite and gneiss are almost everywhere intrusive into the oldest rocks of the district. It is in the granite that the tin veins, and also the richest quartz reefs, occur. The total yield of gold of the various mining centres up to the end of 1905 amounts to 109,464 oz., or an average of 1·71 oz. per ton of ore. As to the future prospects of mining in this district, Mr. Gibb Maitland is confident that, with due regard to the prevailing geological conditions, it will continue to produce gold, tin, and tantalite, the capabilities of the field, despite its relatively long existence, being by no means exhausted.

A. H. F.

VII.—New York State Museum. John M. Clark, Director (N.Y. State Education Department). Bulletin 90, Palæontology 14: Cephalopoda of the Beekmantown [Calciferous] and Chazy Formations of the Champlain Basins. By Rudolf Ruedemann, Assistant Palæontologist. 8vo; pp. 393–528, plates 1–38. Albany, 1906.

THE Silurian region of the Lake Champlain basin has proved remarkably rich in fossil remains, which far exceed in abundance those collections made by Professor James Hall in his pioneer work during the progress of the Geological Survey of 1836–43, chiefly in the Adirondack region.

The attention of palæontologists was directed to the Lake Champlain basin by descriptions from the pen of R. P. Whitfield of the rich fauna derived from the Beekmantown formation at Fort Cassin, Vermont. This led to the investigation of the faunas on the New York side of the basin, of which Dr. Ruedemann's work (dealing exclusively with the Cephalopoda) is an important part.

The author makes use in his work of Hyatt's system in classifying his material, believing that it embodies a true expression of the natural relationship of the forms, so far as the Nautiloid Cephalopods are involved. The generic position of a considerable number of the species are, however, left undecided, being provisionally placed in the genus to which they appear to be most closely affiliated, the imperfection of some of the material at the author's disposal rendering such a course unavoidable.

After some remarks upon the Cephalopods described by E. Billings, from the Quebec Group of Newfoundland, Quebec, and Philipsburg, of which about 49 species were described, but very few figured, the author presents detailed sections of the Beekmantown and Chazy Beds. A description of the species follows, prefaced by a brief note upon the terminology employed, which is that of Hyatt, with some alterations and additions proposed by Holm and others.

The species are carefully and fully described, and well illustrated in the text and in the plates. *A propos* of the latter we are glad to see lithography brought into use, instead of the cheaper but much less satisfactory 'process' methods so often resorted to for illustrations.

Synoptic tables at the end of the specific descriptions show that out of 71 species 24 are regarded as new.

The work concludes with an interesting summary of the relations of the Cephalopod faunas of the Beekmantown and Chazy formations to those of other regions. A bibliography and index are also added.

A. H. F.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—November 21st, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "The Kimeridge Clay and Corallian Rocks of the Neighbourhood of Brill (Buckinghamshire)." By Arthur Morley Davies, A.R.C.S., B.Sc., F.G.S.

The paper contains two principal divisions:—

(1) An account of the section of Rid's Hill, Brill. At the summit are Lower Portlandian sands, not well exposed; below these comes a thickness of about 50 feet of Upper Kimeridge Clay, with only one small exposure of grey shale containing black lignite and a few fossils. At the foot of the hill, a large brickfield shows the following sequence:—

	Feet.
8. Grey, creamy-weathering clay (zone of *Exogyra virgula*)	4
7. Grey, creamy-weathering clays with crushed shells, darker and slightly selenitic towards the base ... ... about	17½
6, 5, & 4. Two bands of creamy limestone, with marly clay between (*Pictonia* cf. *Cymodoce*, *Pholadomya æqualis*)	4
3. Dark grey, brown-weathering clay, with occasional phosphatic nodules	8
2. Black shaly clay, weathering lilac-grey with yellow stains, highly selenitic (*Belemnites abbreviatus*, *B. nitidus*, *Ostrea deltoidea*, *Gryphæa dilatata*, *Trigonia Voltzii*, etc.)	14
1. Band of grey limestone (*Perisphinctes decipiens*, *Trigonia Juddiana*) at the base.	

There have also been dug up, probably from the selenitic clay (No. 2), doggers composed largely of *Serpula tetragona*, Sow., and *Arctica* (*Cyprina*) *cyreniformis* (?), Blake, yielding many other fossils, including *Cardioceras alternans* (von Buch) and *Belemnites nitidus*, Dollf. The possibility of the selenitic clay being Ampthill Clay is discussed, the conclusion being that only Lower Kimeridge Clay is exposed in this section.

(2) The rock of Studley and Arngrove, described by Phillips as an argillaceous chert, is shown to be mainly composed of the globate spicules of the tetractinellid sponge *Rhaxella*. It has a much more limited extension eastward than the geological map would suggest; but, on the other hand, it is found to form part of the outcrop of normal Corallian rocks from Waterperry by Stanton St. John to Holton Wood. Its exact relation to the Oxford Clay is described, and an increased list of fossils is recorded from it.

Palæontological notes are given on certain species of Lamellibranchia and Annelida, chiefly from the Lower Kimeridge Clay.

2. "On the Skull and greater portion of the Skeleton of *Goniopholis crassidens* from the Wealden Shales of Atherfield (Isle of Wight)." By Reginald Hooley, F.G.S.

In the late Autumn of 1904, at a place locally called 'Tie Pits,' near Atherfield Point, a huge mass of the cliff, comprising many thousand tons of the Wealden Shales, subsided, pushing its foot across the beach until below low-water line. As the sea washed away the base, the mass continued to sink, and fresh horizons were denuded. In 1905 a series of heavy 'ground-seas' cast up blocks of limestone and ironstone, containing crocodile bones, which were discovered on the sand between high- and low-watermarks. The skull came ashore in six pieces. Fragments of bones and scutes were constantly picked up; and the author is indebted to Prof. T. McK. Hughes for the block which had been picked up and sent to the Sedgwick Museum at Cambridge. The specimens were derived from a horizon 80 to 90 feet below the top of the Wealden Shales. A history of the British Goniopholidæ from the foundation of the genus by Owen in 1841 is given, and it is noted that the frame in the Mantell Collection, now in the British Museum, not only contains the two type-blocks, but a smaller one with the impression of the orbital region of the skull, a fragment of the frontal bone, and the impression and fragments of a moiety of the right ramus. The skull and bones of the new specimen are next described, and a detailed comparison is instituted between *G. simus* and *G. crassidens*, with the result that the specimen is referred to the latter species, differing in several important particulars from the former. Comparisons are also made with other species of *Goniopholis*, with *Nannosuchus*, and *Oweniasuchus*. In conclusion, the author notes that, while in certain features the species come nearer to the Teleosaurs than *G. simus*, it is farther removed than the latter from them in the position of the posterior nares.

II.—December 5th, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "On the Geological Conditions which have contributed to the Success of the Artesian Boring for Water at Lincoln." By Professor Edward Hull, M.A., LL.D., F.R.S., F.G.S.

This boring has its source of supply in strata which rise to the west, but to the east dip down towards the North Sea. There exists no information as to whether the eastern border of the water-bearing formation thins out against a concealed ridge of Palæozoic rocks. The water-yielding stratum is reddish, soft, porous sand-rock, reached at a depth of 1,561 feet and penetrated to a depth of 474 feet. About one million gallons of water rise to the surface daily. The sand-rock belongs to the New Red Sandstone, which crops out from York to Nottingham with a breadth of about eight miles. The hydraulic pressure at the bottom of the boring is that due to about 2,035 feet, and the friction of the water in percolating the rock accounts for the fact that the water can be pumped down during the day but rises again in the night. The formations penetrated are the following:—Alluvium and Lower Lias 641 feet, Rhætic beds 52 feet, Red Marl and Lower Keuper Sandstone 868 feet, Bunter Sandstone 454 feet. The quantity of water drawn from the New Red Sandstone, at and below the outcrop defined, amounts to not less than 20 million gallons, and the total available quantity of water percolating into the sandstone amounts to about 300 millions.

2. "Notes on the Raised Beaches of Taltal (Northern Chile)." By Oswald Hardey Evans, F.G.S.

The town of Taltal is situated partly on the dry bed of a broad river and partly on a gently inclined plain that fringes the bays of the coastal ranges far to the northward, and runs up the valleys to a considerable altitude and distance from the coast. The material of this plain consists of sands and well-rounded gravel derived from the rocks of the adjacent hills, mingled with shells and some isolated boulders of considerable size. The formation is impregnated with salt, and there protrude through it curiously weathered remnants of former stacks and islets. The plain rises in terraces, the highest of which are somewhat obscure, and sometimes portions of these higher terraces are preserved in the stacks and islets. A second coastal shelf also occurs, marked by a line of shallow caverns, some excavated in igneous rocks. Some, at least, of the shell-accumulations associated with the plain contain pottery, and are associated with Indian kitchen-middens, but the beds of shells in the gravel, containing occasionally whale-bones, give satisfactory evidence of the marine origin of the terraces. Some of these shells are replaced by crystallized brine, and calcium sulphate occurs in some sections. Profound ravines (*quebradas*) occur in the massive rocks bordering the plain, although the climate is now so dry that rain-erosion is practically non-existent.

CORRESPONDENCE.

THICKNESS OF LAND-ICE.

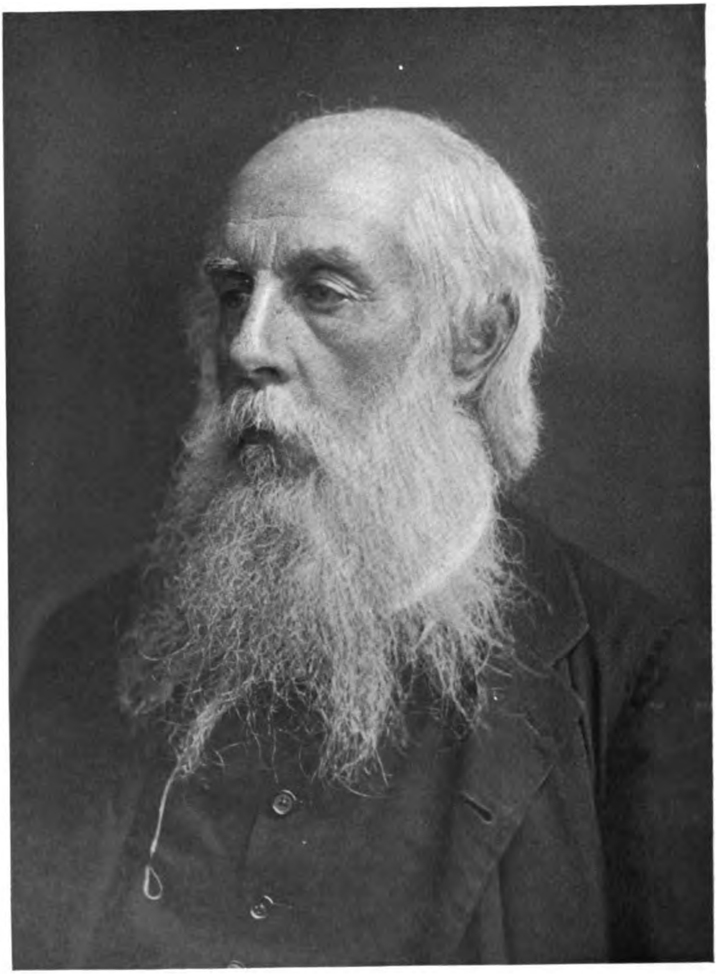
Sir,—I have not followed the discussion to which Mr. Lamplugh alludes in his letter of November 7th, but I should be thankful to be allowed to make a remark upon the final sentence, where he says that "the evidence for the past and present existence of ice of greater thickness than 1,600 feet is so strong that physicists who wish to apply this limitation may be advised, in their own interest, to revise their calculations."

I published a paper "On the Thermal Conditions and Stratification of the Antarctic Ice" in the Phil. Mag. for June, 1879, in which I arrived at the conclusion that supposing the surface at zero Fahr., after the ice had accumulated to the thickness of 740 feet (about), it would begin to melt at the bottom owing to the pressure; but I concluded (p. 385) that "No certain limit can be imposed upon the thickness to which the ice might accumulate, provided the snowfall be more than sufficient to counterbalance the melting at the bottom."

I do not know who the physicists may be to whom reference is made in Mr. Lamplugh's letter, but as I have corresponded with Professor Schwarz upon this subject I have thought it as well to show that for one *my* calculations do not require revision.

O. Fisher.

Graveley, Huntingdon.
December 3rd, 1906.



Yours truly, W. Whitaker

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. II.—FEBRUARY, 1907.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

William Whitaker, B.A. (Lond.), F.R.S., F.G.S., Assoc. Inst. C.E., F.R. San. Inst.;

Past President of the Geological Society, the Geologists' Association, the Norwich Geological Society, the Hampshire Field Club, the Hampshire Literary and Philosophical Society, the Hertfordshire Natural History Society, the South-Eastern Union of Scientific Societies, the Croydon Microscopical and Natural History Club; of Section C, British Association, 1895; and of Section III, Congress of the Sanitary Institute (twice).

(WITH A PORTRAIT, PLATE III.)

AMONG the many distinguished geologists and men of science whom one has been accustomed to meet, year after year, at the gatherings of the Geological Society, the British Association, and the Geologists' Association during the past forty years, none has, by good *camaraderie* and hard work both in the field and study, established a better claim to our warm personal regard and esteem than Mr. Whitaker, whose portrait we present to our readers this month.

William Whitaker was born at 69, Hatton Garden, London, on the 4th May, 1836. Like the forebears of Professor Prestwich and Professor John Ruskin, Mr. Whitaker's father was an old-established wine-importer in Crutched Friars.

His early education was begun in 1846 at a boarding-school in St. John's Wood. After two years at farms in Kent he was transferred to the Grammar School of St. Albans, on the Chalk, Reading Beds, and Glacial Drifts, with which his name and work, as a geologist, were in after years to be so long and intimately connected in the East of England.

From St. Albans he entered University College, Gower Street, in 1852, where, a quarter of a century earlier, Prestwich had been a student. Here he ultimately devoted himself to science, beginning with chemistry and then studying geology under Professor Morris, through whose teaching he gained much valuable geological knowledge, to be applied in later years in the field. He took his B.A. degree in the University of London, with honours in chemistry, in 1855.

It was in his early student days that he became acquainted with Professor T. Rupert Jones, F.R.S., at that time Assistant Secretary to the Geological Society and editor of its Quarterly Journal, working for some months as Professor Rupert Jones' volunteer assistant, and afterwards for a time he was engaged as assistant in the Museum of the Society. Here he developed his interest in geology and bibliographical research, which governed his career in after life.

On the 1st of April, 1857, Whitaker joined the English staff of the Geological Survey of the United Kingdom, under Sir R. I. Murchison, with Ramsay as Local Director, and Aveline, Bristow, Howell, and Hull among the senior officers. He was at first engaged, with Professor E. Hull, T. R. Polwhele, and Hilary Bauerman, on the geology of parts of Oxfordshire and Berkshire, and on the country around Brill, in Buckinghamshire; and later on, with H. W. Bristow, on Berkshire and the northern part of Hampshire. Early in 1859 he was elected a Fellow of the Geological Society, and now is 29th Fellow in seniority. In 1863 Mr. Whitaker was promoted to the rank of Geologist.

The writer recalls with pleasure a week's holiday spent with Whitaker in Bath, during the Meeting of the British Association in 1864, when several agreeable evenings were passed with the late William Pengelly (familiarly known at that time as *Pun*-gelly), Professor Rupert Jones, Joseph Beck, and some others, when much innocent fun and enjoyment at dinner relieved the more serious business of the day's scientific proceedings. Many pleasant geological excursions were also taken to Frome, the Vallis, to Watchet and elsewhere.

Proceeding on in his work he took up the original survey of the geology of the London Basin, particularly the Chalk and Eocene beds of the Southern and Western Tracts from Newbury eastwards into Surrey, Southern Bucks, Middlesex, Herts, Essex, and Kent.

In his researches, which extended for more than thirty years, Whitaker worked over ground much of which had been rendered classical by Prestwich's earlier researches, following, more than any other man had done, in his footsteps. Speaking of this period of Prestwich's work (1841–1860), Whitaker remarked "that it might well be called 'the Prestwichian period,' as it was he who first clearly made out the structure of the London Basin" (Mem. Geol. Surv., vol. iv, p. 395). The Drift Survey of the London area was in 1869 carried out mainly under his guidance, though nominally under the superintendence of Mr. Bristow.

Later on we find Whitaker working out the geology of Walton-on-the-Naze and Harwich and other parts of the counties of Essex, Suffolk, and Cambridgeshire. Indeed, it may be said that the whole of Essex and Suffolk and parts of West Norfolk and Cambridgeshire were surveyed by him, with the aid of colleagues who worked under his direction.

Among those who, at various times, worked under his superintendence were Richard Trench, H. B. Woodward, W. H. Penning, W. H. Dalton, Thomas Adams, F. J. Bennett, W. A. E. Ussher, J. H. Blake, A. C. G. Cameron, C. E. Hawkins, S. B. J. Skertchly, Clement Reid, and A. J. Jukes-Browne. Although for many years he thus superintended the work of others, it was not until 1882 that he was appointed District Surveyor, a post which he held until he retired from the public service on October 22nd, 1896. During the later years of his official career he was stationed at Southampton, and surveyed some portions of South Hampshire, while at the same time he was superintending the re-surveys in progress in no less than seven other counties, Bedford, Berks, Bucks, Dorset, Northants, Oxford, and Wilts.

It is on record among the anecdotage of the Survey hammerers, that upon one occasion Murchison (observing the exemplary industry and excellence of Whitaker's work in the field) said to his lieutenant, Professor (afterwards Sir) A. C. Ramsay, "Don't you think, Ramsay, that Whitaker has worked long enough in the Eastern Counties, where he gets nothing but soft squashy materials, and no good hard rocks to hammer? We might send him to the North or West, and give him some decent *solid geology* instead of this interminable Chalk, London Clay, and Drift"; to which Ramsay replied, "But, Sir Roderick, I assure you Whitaker *likes to work where he is.*" "If that is really the case," said Sir Roderick, "pray let him stay there, but I am sorry for him all the same." And he stayed there and did very excellent geological work for very many more years.

Whitaker was early in the field as an ardent student of subaërial denudation, and communicated an excellent paper on "Cliffs and Escarpments of the Chalk and Tertiary Strata" to the Geological Society on May 8th, 1867; the full text of which, not being regarded apparently as suitable for the Quarterly Journal, appeared in the GEOLOGICAL MAGAZINE in that year, p. 447, and Part II, p. 483. It is now regarded as a geological classic.[1]

As a corollary to Mr. Whitaker's geological labours in maps and memoirs, which by a reference to the annexed list of his published works will be seen to be very extensive, he has always had a strong passion for bibliographical research and the making of lists of references to the labours of all previous writers in whatever branch of geology upon which he, or his friends and colleagues, were specially engaged. One of his activities in this direction led him to edit a "Geological Record," which, owing in part to the arduous nature of his other work, but perhaps in larger measure owing to the shortcomings of some of those who had promised to help and failed to produce their MSS. when required, he was compelled at length to relinquish, after carrying it on for six years.

Another subject to which he has devoted much attention has been the accumulation of evidence connected with the sinking of wells, believing, like the ancients, that by seeking diligently in these places he would in time arrive at the home of TRUTH.

He retired from the Geological Survey in October, 1896, and has since resided at 3, Campden Road, Croydon. He has been for more than thirty years one of the leading authorities upon questions of water-supply for towns and public buildings, principally in the eastern and south-eastern counties of England. He has also reported on the Kent coal borings.

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[1] See the very high commendation of this memoir by Charles Darwin in his work on "The formation of Vegetable Mould through the action of Earthworms," 8vo, 1883 ed., p. 234 (Murray).

No man has been more assiduous in helping others individually or by taking part in the ordinary meetings, councils, and committees of various learned societies and field clubs. As a director of excursions he has ever proved a popular, a ready, and most able guide, as may be gathered from the Proceedings of the Geologists' Association in particular. Recognition of his services has been frequently shown by his election to Presidential chairs, an honour not without attendant labour, if we may judge from the record of his addresses. Other recognitions have been given in the awards by the Council of the Geological Society in 1886 of the Murchison Medal, and in 1906 of the singularly appropriate Prestwich Medal, which, as the President of the Geological Society (Dr. J. E. Marr) said, had been awarded "as an acknowledgment of the value of your researches among the Tertiary strata of the London and Hampshire Basins . . . . which were advanced in a high degree by the founder of the medal. You have also followed in the footsteps of Prestwich in matters of economic geology—the question of water supply and the study of underground geology—for which you, the recipient of the medal, like its founder, have done so much."

Twenty years earlier, in 1886 (when awarding Mr. Whitaker the Murchison Medal), Professor Bonney said: "Your papers on the western end of the London Basin and on the Lower London Tertiaries of Kent deserve to be ranked with the classic memoirs of Prestwich as elucidating the geology of what I may call the Home District."

Mr. Whitaker claims one negative virtue, he does not smoke; and one positive virtue, he walks.

The following is a list of Mr. Whitaker's published papers:—

1. *Papers published in the* GEOLOGICAL MAGAZINE.

1864. "On some Evidence of there being a Reversal of the Beds near Whitecliff Bay, Isle of Wight": vol. i, pp. 69–71.
"On the Cliffs at Folkestone": ibid., pp. 212–215.

1867. "On Subaërial Denudation, and on Cliffs and Escarpments of the Chalk and Lower Tertiary Beds": vol. iv, pp. 447–454, 483–493. Reprinted, with small additions, 8vo, Hertford, pp. 28. See also vol. v, pp. 46–47.

1869. (With H. W. BRISTOW.) "On the Formation of the Chesil Bank, Dorset": vol. vi, pp. 433–438, pl. xv. See also pp. 574–575.
"On a Raised Beach at Portland Bill, Dorset": ibid., pp. 438–440.
"On the Connection of the Geological Structure and the Physical Features of the South-East of England with the Consumption Death-rate": ibid., pp. 499–505.

1871. "On the Chalk of the Cliffs from Seaford to Eastbourne, Sussex": vol. viii, pp. 198–200.

1872. "On the Occurrence of the 'Chalk Rock' near Salisbury": vol. ix, pp. 427–428. Reprinted from Mag. Wilts. Archæol. N.H. Soc., vol. xiii (1871), pp. 92–93.

1873. "Remarks on the Section at Shaw Clay Pit": vol. x, pp. 142–143. Printed in advance of Trans. Newbury District Field Club, vol. ii (1878), pp. 3–6.

1886. "On a Recent Legal Decision of Importance in Connection with Water Supply from Wells": dec. III, vol. iii, pp. 111–114. Reprinted from Trans. San. Inst., vol. vii.
"On the Waterworks at Goldstone Bottom, Brighton": ibid., pp. 159–161. (Abstract, on p. 32, alone referred to in Index.)

1890. "Coal in the South-East of England": dec. III, vol. vii, pp. 13–14.

"Suggestions on Sites for Coal-search in the South-East of England": ibid., pp. 514–515. Reprinted, with a little difference, from Brighton and County Mag., pp. 170–172.

1904. "On a Great Depth of Drift in the Valley of the Stour": dec. v, vol. i, p. 511; and Rep. Brit. Assoc. for 1904, pp. 343–344 (1905).

2. *Geological Survey Publications.*

(*a*) List of Sheets of the Map of the Geological Survey prepared by or partly by Mr. Whitaker: 1 (N.W., S.W., S.E.), 3, 6, 7, 8, 12, 13, 14, 45 (S.E.), 46 (N.W., N.E., S.W., S.E.), 47, 48 (N.W., N.E., S.E.), 49 (N., S.), 50 (N.E., S.W.), 65, 69; besides superintending the survey of several others. And of the New Series, Sheets 299, 315, 316; besides superintending the re-survey of others.

(*b*) Sheets of the Horizontal Sections: 56, 73, 74, 79, 84, 120, 125.

(*c*) Memoirs.

1861. (With E. Hull.) "The Geology of Parts of Oxfordshire and Berkshire."

1862. (With H. W. Bristow.) "The Geology of Parts of Berkshire and Hampshire" (small part).

1864. "The Geology of Parts of Middlesex, Hertfordshire, Buckinghamshire, Berkshire, and Surrey."

(With A. H. Green.) "The Geology of the Country round Banbury, Woodstock, Bicester, and Buckingham" (small part).

1872. "The Geology of the London Basin . . . The Chalk and the Eocene Beds of the Southern and Western Tracts."

1875. "List of Books, Papers, etc., in the Geology of Rutland, etc.": pp. 294–301.

"Guide to the Geology of London and the Neighbourhood." 2 editions; others in 1880, 1884, 1889, 1901.

1876. (With H. B. Woodward.) "Chronological List of Books, Papers, etc., on the Geology, Mineralogy, Palæontology, etc., of Gloucestershire and Somersetshire": pp. 216–255 of "Geology of East Somerset and the Bristol Coalfields."

1877. "The Geology of the Eastern End of Essex" (Walton Naze and Harwich).

1878. (With W. H. Penning and others.) "The Geology of the North-West Part of Essex and the North-East Part of Herts . . ."

1880. "The Geology of the Neighbourhood of Colchester" (small part).

1881. "List of Works on the Geology of Cambridgeshire": pp. 170–   of "The Geology of the Neighbourhood of Cambridge."

(With F. J. Bennett and J. H. Blake.) "The Geology of the Neighbourhood of Stowmarket."

(With H. B. Woodward.) "List of Papers, etc., on the Geology of Norfolk": pp. 171–204 of "The Geology of the Country around Norwich."

1885. "The Geology of the Country around Ipswich, Hadleigh, and Felixstow."

"List of Works on the Geology, etc., of Denbighshire and Flintshire": pp. 59–73 of "The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn."

(With W. H. Dalton.) "Chronological List of Books and Papers relating to the Geology of Lincolnshire and East Nottinghamshire": pp. 164–176 of "The Geology of the South-West Part of Lincolnshire . . ."

1886. (With W. H. Dalton.) "The Geology of the Country around Aldborough, Framlingham, Orford, and Woodbridge."

(With F. J. Bennett and J. H. Blake.) "The Geology of the Country between and south of Bury St. Edmunds and Newmarket."

1887. (With W. H. Dalton.) "The Geology of the Country around Halesworth and Harleston."

"List of Works on the Geology, Mining, Mineralogy, and Palæontology of Derbyshire": pp. 185–202 of "The Geology of . . . North Derbyshire."

"The Geology of Southwold and of the Suffolk Coast from Dunwich to Covehithe."

1889. "The Geology of London and of Part of the Thames Valley." 2 vols.
1891. (With H. B. Woodward and others.) "The Geology of Parts of Cambridgeshire and of Suffolk."
1893. (With S. B. J. Skertchly and others.) "The Geology of South-Western Norfolk and of Northern Cambridgeshire."
1898. (With A. Strahan.) "List of Books, Papers, Maps, etc., on the Geology, Mineralogy, and Palæontology of Dorset": pp. 241–268 of "The Geology of the Isle of Purbeck."
1899. (With A. J. Jukes-Browne.) "The Geology of the Borders of the Wash."
(With C. Reid.) "The Water Supply of Sussex from Underground Sources."
1902. "The Water Supply of Berkshire from Underground Sources," by J. H. Blake (contributions to).
"The Geology of the Country around Southampton," by C. Reid (contributions to).
1904. "The Water Supply of Lincolnshire from Underground Sources" (contributions to).
1906. "The Water Supply of Suffolk from Underground Sources."

3. *Papers published in the Quarterly Journal of the Geological Society of London.*

1861. "On the 'Chalk Rock,' the Topmost Bed of the Lower Chalk . . . ": vol. xvii, pp. 166–170.
"On a Reconstructed Bed on the Top of the Chalk and Underlying the Woolwich and Reading Beds": ibid., pp. 527–528.
1862. "On the Western End of the London Basin; on the Westerly Thinning of the Lower Eocene Beds in that Basin; and on the Greywethers of Wiltshire": vol. xviii, pp. 258–274.
1865. "On the Chalk of the Isle of Thanet": vol. xxi. pp. 395–398.
"On the Chalk of Buckinghamshire, and on the Totternhoe Stone": ibid., pp. 398–400.
"On the Chalk of the Isle of Wight": ibid., pp. 400–406.
1866. "On the 'Lower London Tertiaries' of Kent": vol. xxii, pp. 404–435, pl. xxii.
1869. "On the Succession of Beds in the 'New Red' on the South Coast of Devon and on the Locality of a New Specimen of *Hyperodapedon*": vol. xxv, pp. 152–158.
1871. "On the Chalk of the Southern Part of Dorset and Devon": vol. xxvii, pp. 93–100.
"On the Cliff-Sections of the Tertiary Beds west of Dieppe in Normandy, and at Newhaven in Sussex": ibid., pp. 263–268.
1874. "On the Occurrence of Thanet Beds and of Crag at Sudbury, Suffolk": vol. xxx, pp. 401–405.
1877. "Note on the Red Crag": vol. xxxiii, pp. 122–125.
1884. "Introductory Notes on the Eocene Beds." In Lieut.-Colonel Godwin-Austen's paper "On the New Railway-Cutting at Guildford": vol. xl, pp. 599–600.
1886. "On some Borings in Kent: A Contribution to the Deep-seated Geology of the London Basin": vol. xlii, pp. 26–48, pl. iii.
1887. "Further Notes on the Results of some Deep Borings in Kent": vol. xliii, pp. 197–205.
1888. ["On Specimens from the Deep Boring at Streatham"]: Proc. Geol. Soc., No. 528, pp. 9–10, and No. 529, p. 23.
1890. "On a Deep Channel of Drift in the Valley of the Cam, Essex": vol. xlvi, pp. 333–340.
1894. (With A. J. Jukes-Browne.) "On Deep Borings at Culford and Winkfield, with Notes on those at Ware and Cheshunt": vol. L, pp. 488–514.
1899. Anniversary Address of the President ("Geology in reference to Water Supply, etc.," pp. lxix–lxxxiii): vol. lv, p. liii.
1900. Anniversary Address of the President ("Underground Geology," pp. lxix–lxxxvii): vol. lvi, pp. li–lxxxviii.
1903. "On some Well-Sections in Suffolk": vol. lix, pp. 33–50.

4. *Papers published in the Proceedings of the Geologists' Association.*

1878. "Excursion to the North Downs, Surrey": vol. v, no. 8 (? 1879), pp. 495–497.

1880. "Excursion to Upnor": vol. vi, no. 7, pp. 336–337.

1883. "The Geology of the District [to be] visited during the Whitsuntide Excursion and Excursion to Hunstanton": vol. viii, pp. 124, 132–141.

1886. "Excursion to Canterbury, Reculvers, Pegwell Bay, and Richborough": vol. ix, no. 4, pp. 168–177.

1887. "Excursion to Salisbury and Stonehenge": vol. ix, no. 8, pp. 522, 531.

1888. "Easter Excursion, 1887 [Bognor, etc., and] Preliminary Excursion to Southampton": vol. x, no. 4, pp. 132-141.

"Excursion to Sudbury, Suffolk": ibid., pp. 187–191.

1889. "Whitsuntide Excursion to the Crag District": vol. xi, no. 5, pp. lxviii–lxxii.

1901. "Twelve Years of London Geology (General, Recent, and Drift)": Presidential Address, vol. xvii, pt. 2, pp. 81–109.

1902. "A Dozen Years of London Geology (Eocene, Chalk, and Underground)": Presidential Address, vol. xvii, pt. 6, pp. 342–364.

(With O. A. Shrubsole.) "Excursion to Reading": ibid., pts. 7, 8, pp. 381–383.

(With C. Bird.) "Excursion to Frindsbury and Upnor": ibid., pts. 9, 10, pp. 397–398.

1904. "Excursion to the Croydon Bourne": vol. xviii, pt. 7, pp. 388–389.

1906. "Excursion to Battle and Netherfield": vol. xix, pt. 10, pp. 449–451.

5. *Papers on Wells (by Counties) other than those in the Geological Survey Memoirs.*

1885. "Some Hertfordshire Well-Sections": Trans. Herts. N.H. Soc., vol. iii, pt. 5, pp. 173–180.

1886. "Some Surrey Wells and their Teachings: with sections of Wells and Deep Borings in the Surrey Part of the London Basin": Trans. Croydon Micr. N.H. Club, vol. iii, pp. 43–69.

"Some Essex Well-Sections": Trans. Essex Field Club, vol. iv, pt. 2, pp. 149–170.

1889. "Hampshire Well-Sections": Papers Hants. Field Club, No. iii, pp. 17–36.

"Some Essex Well-Sections" (part ii): Essex Nat., vol. iii, pp. 44–54.

1890. "Some Hertfordshire Well-Sections" (second paper): Trans. Herts. N.H. Soc., vol. vi, pt. 2, pp. 53–64.

1892. "Some Essex Well-Sections" (part iii): Essex Nat., vol. vi, pp. 47–60.

1893. (With H. B. Woodward) "Notes of some Somerset Wells": Proc. Bath N.H. Antiq. Field Club, vol. vii, No. 4, pp. 340–345.

1895. "Some Suffolk Well-Sections": Rep. Brit. Assoc., pp. 436–440.

"Some Surrey Wells" (second paper): Trans. Croydon Micr. N.H. Club, vol. iv, pp. 132–150.

1896. "Some Essex Well-Sections" (part iv), with some Water-Analyses: Essex Nat., vol. ix, pp. 167–190.

1897. "Some Yorkshire Well-Sections": Proc. Yorksh. Geol. Soc., vol. xiii, pt. 2, pp. 192–198.

1898. "Some Middlesex Well-Sections": Trans. Brit. Assoc. Water Eng., vol. ii, pp. 76–109.

"Hampshire Well-Sections" (second paper): Papers Hants. Field Club, vol. iv, pt. 1, pp. 21–45.

1901. "Kentish Well-Sections in the Rochester District": Rochester Naturalist, vol. iii, pp. 23–27, 38–41, 55–62.

"Some Surrey Wells" (third paper): Trans. Croydon Micr. N.H. Club, vol. v, pp. 30–50.

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II.—On the Ashgillian Series.

By J. E. Marr, Sc.D., F.R.S.

In my Address to the Geological Society in 1905 I proposed the use of the term Ashgillian for the uppermost series of the Ordovician System, but did not discuss therein at length the exact relationship of the beds to which the term was applied, with the underlying and overlying strata. An examination of the literature treating of these rocks showed that there was a considerable amount of confusion with regard to these strata, and it is the object of this paper to clear this up and to indicate what deposits are actually referable to the Ashgillian division.

I. Historical.

In the Introduction to the "Synopsis of the Classification of the British Palæozoic Rocks" (which is undated, though a postscript is dated July 19th, 1855), Sedgwick gives the Bala Group as constituting the whole of his Upper Cambrian, while the Arenig slates and porphyries are placed in the upper division of his Middle Cambrian. He divides the Bala Group as follows:—"*a*. Lower Bala rocks. (1) A great series of dark and sometimes earthy slate. (2) A great series of slates, flags, and grits, ascending to the Bala Limestone.—*b*. Upper Bala rocks. Under this term are included: (1) The Bala and Hirnant Limestone and the Llandeilo calcareous flag. (2) Flagstones, slates, calcareous beds, and shelly sandstones of Caer Caradoc. The whole series ending, in North Wales, with slate and flagstone; and, in South Wales, with slates, grits, and coarse conglomerates. The group of very great thickness."

In this scheme the term Upper Bala was used in a wider sense than that in which it was subsequently used by Salter with Sedgwick's consent.

In "The Catalogue of the Collection of Cambrian and Silurian Fossils in the Geological Collection of the University of Cambridge," published by the University Press in 1873, the term "Upper Bala" was restricted, and a new term "Middle Bala" introduced and adopted "for the Bala Limestone and its associated sandstones and slates, several thousand feet thick in N. Wales . . . ."

On p. 39 of the Catalogue the following is given as the extent of the Middle Bala Group: "Professor Sedgwick only includes in this group the 9,000 feet of beds, chiefly arenaceous, slaty, and with some calcareous bands, which lie over the dark earthy slates of the Arenig section (Lower Bala). The group extends a short distance, probably a couple of hundred feet, above the Bala Limestone. But it does not include the Hirnant Limestone, which is the base of the Upper Bala group next described. It appears to represent in mass the whole of the Caradoc Sandstone proper, in Shropshire."

We here find a definite statement that the Hirnant Limestone is the base of the Upper Bala Group.

On pp. 72–83 the Upper Bala fossils are catalogued, and at the head of p. 72 the following grouping is given:—

"Upper Bala Group, Sedgw. (restricted in 1866). The Upper Bala of the synopsis includes the Bala Limestone, now *Middle Cambrian*.[1]

"1. *Hirnant Limestone* and Llanfyllin Beds, viz., pale-coloured slates above the Bala Limestone. Ash Gill slates, etc., above the *Coniston Limestone*.

"2. *Llandovery Rocks* (Phillips, Salter, Lyell—*Lower Llandovery* of the Survey)."

The same classification is given in somewhat different words on p. 26 (text).

With regard to the restriction of the term in 1866 I have searched in vain for any printed record of such restriction, and believe that it was the result of conversation between Sedgwick and Salter, for in a note on p. 26 of the Catalogue Salter writes: "Prof. Sedgwick trusts me to arrange them [the Bala fossils] according to the present state of our knowledge, 1867. The Bala Group or Upper Cambrian of Sedgwick therefore consists of:—

UPPER CAMBRIAN (Sedg.).
Lower Bala = Llandeilo Flag (*Upper Llandeilo*, Geol. Survey, the Arenig being the lower).
Middle Bala = Caradoc Sandstone and Bala rocks (Geol. Survey and Sir R. I. Murchison).
Upper Bala = Caradoc shales, Hirnant Limestone, and Lower Llandovery rock (Geol. Survey)."

It is clear to me that the Upper Bala as defined by Salter in the paragraph I have quoted is very different from the Ashgillian as I propose to use it, so far as the Bala region is concerned, for he definitely takes the base of the Hirnant Limestone for its base, whereas I propose to include beds some way below this limestone, which beds, I hope to show, are equivalent to the Ashgill Beds, which Salter includes in the Upper Bala.

The position of the summit of the Upper Bala Group as defined by Salter is even more unsatisfactory. We have seen that he divides the Upper Bala Group into two sub-groups, viz., the Hirnant Limestone, etc., below, and the Llandovery above.

Salter himself says of them (Cat. Camb. and Sil. Foss., p. 72): "The fossils of these two divisions are arranged together, as it is clearly impossible always to draw a line between them; they form, indeed, one series. But the list is kept in *two separate columns here*, as each group contains a few peculiar species."

The Llandovery Beds here mentioned (now called Lower Llandovery) are at the present day, by general consent, bracketed with the May Hill Beds (Upper Llandovery) to form the basal series of the Silurian system. We are therefore concerned with the rocks containing the fossils placed by Salter in the columns of the Catalogue headed "Upper Bala proper." Twenty-two forms are recorded in these columns. The first entry, *Nidulites favus*, is clearly placed in the wrong column owing to a clerical error. Two trilobites are given, viz. *Phacops obtusicaudatus* and *Proetus* sp., from Coldwell and the equivalent strata of Helm(s) Knot, Dent. Salter elsewhere (Cat., p. 26) brackets these Coldwell Beds with the Ashgill Beds—an extraordinary error, the Coldwell Beds actually belonging to the Lower Ludlow

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[1] The word Cambrian is clearly a misprint for Bala.

Group. We are left with 19 forms, viz.: 2 Corals, 2 Bryozoa, and 15 Brachiopods, of which 11 are *Orthides*, most of which have a long range. This attempted definition of the "Upper Bala proper" by its included fauna is almost as unsatisfactory as the attempt to draw definite lines at its base and summit. The one satisfactory determination in the Catalogue is that of the position of the Ashgill Beds.[1]

Having now considered the "Upper Bala" Group as originally defined in the Cat. Camb. and Sil. Foss., we may pass to the consideration of other contributions to the study of the highest Ordovician strata at home and abroad.

The British area where the Ashgillian rocks were first accurately separated from those of Middle Bala (Caradocian) age was, as has been already stated, that of Lakeland, and we may now consider the work which has been done in that region.

The Upper Bala Beds of the Lake District proper, unlike those of Wales, have from the time of the restriction of the term in 1866 been correctly grouped, save that Salter included the Coldwell Beds (of Lower Ludlow age) with the Ashgill Beds proper, but his reference of the Ashgill Beds to the Upper Bala showed that these beds were recognised by him as separable from the Middle Bala Group.

Professor T. McK. Hughes in 1876 showed me that the shales of the Sedbergh area, which he spoke of as the "Fairygill Shales," were, like the Ashgill Shales, distinguishable from the "Coniston Limestone" below (which contains a Middle Bala fauna) by their organic contents, and he discovered *Strophomena* (?) *siluriana* in the Ashgill Shales of Ashgill, he and the Rev. H. G. Day having previously found it in Fairygill, etc., and sent specimens to Davidson, who described them in the monograph on the Brachiopods published by the Palæontographical Society in 1870. Professor Hughes never published his views, but to him belongs the credit of showing that Salter's Ashgill Beds were more than a local development of beds at Ashgill.[2]

In a paper which appeared in the Quarterly Journal in 1878 I gave a short list of fossils from the Ashgill Shales, but at that time had not recognised a calcareous deposit below the base as belonging to the Ashgill Group. I first referred that limestone to the Ashgill Series in my Sedgwick Essay (1883) in the following words:—

"*Upper Bala Series.* The Ashgill Shales of Sedgwick and Salter succeed the Coniston Limestone, and have a very different fauna. They are never more than 200 feet thick, and consist of a lower stage of grey crystalline limestone, succeeded by poorly cleaved bluish or blackish shales." Then follows a list of fossils, of which those occurring in the lower (calcareous) stage are marked by an asterisk. Among these are *Caryocystites Davisii* and *Staurocephalus clavifrons*. As both limestone and shales are developed in the quarry of the typical locality, Ashgill, it seems peculiarly appropriate, in the absence of any accurate definition of the limits of the so-called Upper Bala Beds, to use the name of this locality in connection with the division, as I suggested in my Address to the Geological Society in 1905.

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[1] I have found it necessary to criticise adversely some of Salter's conclusions. It is only fair to state that at the time when the Cat. Camb. and Sil. Foss. was compiled he was in deplorable health; also that he was unacquainted with the rocks in the field whose fossils he was arranging and cataloguing. I need hardly mention the respect I have for the work he did among the Lower Palæozoic fossils.

[2] There is reason to believe that the name Ashgill Beds was originally suggested to Salter by Aveline, who separated them from the "Coniston Limestone" proper: at any rate, Salter proved the distinctness of the two groups on palæontological grounds.

In 1892 (Geol. Mag., Dec. III, Vol. IX, p. 97) I published a paper on "The Coniston Limestone Series." In this paper separate lists of the *Staurocephalus* Limestone and Ashgill Shale divisions of the Ashgillian are given, but the Keisley Limestone fossils are wrongly placed with the Caradocian fossils of the Sleddale group.

The true age of this Keisley Limestone was proved by Mr. F. R. Cowper Reed.[1] In his two papers on this limestone he shows that its fauna appertains to the Upper Bala (Ashgillian), and not to the Middle Bala (Caradocian).

Last year I was able to show that the *Staurocephalus* Limestone of the Cross Fell Inlier, previously described by Professor Nicholson and myself, was *in* the Keisley Limestone and not *above* it as we had wrongly concluded. The Ashgillian Beds of the North of England are therefore separable into two divisions—

Ashgill Shales.
Staurocephalus Limestone (with Keisley Limestone).

Turning now to South Wales, we find the most satisfactory development of Ashgillian Beds, so far as Britain is concerned, in that area. These beds were classified and described by the late Mr. T. Roberts and myself in 1885 in a paper in the Quarterly Journal of the Geological Society (vol. xli, p. 476). We divided the beds as follows:—

Slade Calcareous Shales.
Redhill Shales.
Sholeshook Limestone.

We also showed that the Sholeshook Limestone was comparable with the *Staurocephalus* Limestone of Lakeland, the Rhiwlas Limestone of the Bala area, and other deposits elsewhere, and that the Redhill Beds were comparable with the Ashgill Shales. The Slade Beds presented lithological characters differing from those of other known areas possessing Ashgillian rocks, and there is still some uncertainty concerning their equivalents elsewhere, and accordingly we are yet uncertain as to the precise position of the line marking the top of the Ashgillian Beds of some districts. To this point I shall recur later.

In this paper sufficient fossil lists were given to show the marked difference between the fauna of the Caradoc Beds and that of the overlying Ordovician strata, and the latter were shown to be widely spread in the British Isles and to be represented by beds containing similar faunas on the Continent, although the equivalence of some of the Scandinavian beds with the beds of Ashgill had previously been asserted by one of the authors and likewise by Dr. S. L. Törnquist.

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[1] Q.J.G.S., vol. lii, p. 407, and vol. liii, p. 67.

The distinctness of the Caradocian and Ashgillian Series, over wide areas, as based upon lithological characters and faunas, was thus for the first time clearly brought out, and a fairly definite base and summit for the series which I here speak of as Ashgillian was determined. The Ashgillian Series was, in fact, here clearly described as a group worthy of separation from the Caradocian series beneath.

Our classification of these South Welsh deposits has subsequently been confirmed by the officers of the Geological Survey, and later by Mr. D. C. Evans in an admirable paper on the Ordovician of Western Caermarthenshire.[1]

Let us return for a moment to North Wales. The fossils of the Rhiwlas Limestone undoubtedly show its relationship to the Sholeshook and *Staurocephalus* Limestones, and prove its distinction from the Bala Limestone of Caradocian age. This distinction, as I stated in my Presidential Address in 1905, was clearly suspected by a member of the Geological Survey in 1847.

In that address I divided the Ashgillian Beds of North Wales as follows:—

Hirnant Limestone.
Shales.
Rhiwlas Limestone.

There is still much work to be done among these North Welsh rocks. In 1880[2] I referred a calcareous grit with *Echinosphærites*, "by the roadside about a quarter of a mile south-west of Maeshir," to the "Upper Bala Beds." This is probably correct, but a further reference of the *Orthis alternata* beds of Cerrig-y-druidron to this series is almost certainly an error.

When the Ashgillian Beds of this region are eventually defined the definition will undoubtedly be facilitated in consequence of Mr. T. Ruddy's paper on the area.[3] It is quite clear that some of the rocks described by Mr. Ruddy belong to the Ashgillian division. Miss Wood (Mrs. Shakespear) and Miss Elles have obtained undoubted Ashgill Shales with *Phacops mucronatus* near Conway (Q.J.G.S., vol. lii, p. 273).

As in the case of South Wales, so here, we are in difficulty as to the precise position of the upper limit of the Ashgillian strata.

In 1882[4] Professor Lapworth described the Girvan succession in Ayrshire. At the top of the Ordovician system he places the Drummuck Mudstones, with the following subdivisions:—

Upper Mudstones, Ladyburn.
Starfish Band, Quarrel Hill.
Lower Mudstones, Drummuck.
Basal Sandstones, Auld Thorns.

In our paper on Haverfordwest Mr. Roberts and I remarked that "the Starfish Bed of Professor Lapworth . . . . may possibly be the representative of this [Sholeshook Limestone] in the Girvan area. It also contains *Staurocephalus globiceps*." There is very little doubt as to the correctness of this correlation, in which case the overlying Ladyburn Mudstones are the probable equivalents of the Ashgill Shales.

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[1] Q.J.G.S., vol. lxii (1906), p. 597.
[2] Q.J.G.S., vol. xxxvi (1880), p. 277.
[3] Q.J.G.S., vol. xxxv (1879), p. 200.
[4] Q.J.G.S., vol. xxxviii (1882), p. 537.

It must be borne in mind that as there is stratigraphical conformity between the Ordovician Hartfell Shales and Silurian Birkhill Shales of the Moffat area, the uppermost portion of the graptolite-bearing Hartfell Shales must also be referable to the Ashgillian Series.

In Ireland beds of Ashgillian age have been detected in various parts. In 1896 Messrs. Gardiner & Reynolds[1] described the limestone of the Chair of Kildare, which with previous writers they refer to the Coniston Limestone, and in 1897 the same authors[2] describe, among other rocks, the Portraine Limestone, and state that it is comparable to the Chair of Kildare Limestone on the one hand and on the other to the Keisley and Sholeshook Limestones of Great Britain. Each of these deposits, therefore, belongs to the Ashgillian Series.

But the most interesting Irish development of Ashgillian age is found near Pomeroy. The fauna of these rocks has long been known, having been described in 1863 in Portlock's "Report on the Geology of . . . Londonderry . . . Tyrone, and Fermanagh."

In our paper on Haverfordwest Mr. Roberts and I state that the group of fossils characteristic of the Sholeshook Limestone "appears to occur at Desertcreat[e], Tyrone," and we enumerate species common to the South Welsh and Irish areas, and state that fossils from the Irish locality seem to show that the representatives of the Redhill stage occur there also.

Recently this tract has been studied by a party of Cambridge geologists, and an outline of their results has been published in the Geological Magazine by Mr. W. G. Fearnsides.[3] The beds referred to the Ashgillian Series are there spoken of as the Desertcreate Group. It shows the Drummuck facies, and the point of particular interest is the discovery of graptolites of Upper Hartfell age associated with fossils characteristic of the non-graptolitic facies of Ashgillian deposits. The subdivisions of the Desertcreate Group will be found on p. 422 of Mr. Fearnsides' notice, and need not be repeated here.

Abroad the representations of the Ashgillian Series are known only in Scandinavia and Russia. In 1879 S. L. Törnquist,[4] who had examined my specimens of Ashgill fossils and afterwards was taken over the Lake District section by my brother, correlated the Ashgill Shales with the 'Brachiopod-schists' of Sweden, and in 1882[5] I pointed out that they were comparable with the lower part only of these Brachiopod-schists. Later in our Haverfordwest paper Mr. Roberts and I showed that both *Staurocephalus* Limestone and Ashgill Shales were represented in Sweden.

The *Leptæna* Limestone of Dalarne has been referred to various horizons, but Schmidt's work in the Baltic provinces has shown that it is clearly equivalent to stage F of Russia, and it must therefore be

[1] Q.J.G.S., vol. lii, p. 587.
[2] Q.J.G.S., vol. liii, p. 520.
[3] Geol. Mag., Dec. V, Vol. III, p. 421.
[4] Öfv. af k. Vetensk. Akad. Förhandl., p. 63.
[5] Q.J.G.S., vol. xxxviii, p. 313.

intermediate in age between the *Trinucleus* Shales and the *Lobiferus* Beds of Dalarne, the former being of Caradocian and the latter of Birkhillian age. The general correspondence of its fauna with that of the Ashgillian Beds of Britain indicates its general Ashgillian age, but there are certain differences which suggest that beds of other ages are also represented in the *Leptæna* Limestone.

II. LITHOLOGICAL CHARACTERS.

There is a striking similarity in the lithological characters of some of the deposits of Ashgillian age over wide areas. Leaving out of account the Slade Beds of South Wales and certain deposits which in other areas are doubtfully Ashgillian, we find a widespread distribution of lower calcareous and upper argillaceous strata. The calcareous division in Cumberland, Wales, parts of Scandinavia, and probably elsewhere is marked by a greyish, somewhat argillaceous limestone with calcareous shales, each weathering olive-green. With these are purer white limestones, which often assume a markedly crystalline character, as at Keisley and the Chair of Kildare. The overlying argillaceous beds are often bluish-grey and not very markedly laminated sandstones. There is a very decided resemblance between these mudstones as found in the Lake District, North Wales (Conway), South Wales, and in parts of Sweden.

III. FOSSILS.

The fauna of the Ashgillian Beds is very rich, but comparatively little is yet known of it. When the fossils have been collected as assiduously as those of the Chalk (for instance) we shall probably find a marked contrast between the fauna of the Ashgillian Series and those of the Caradocian below and Valentian (Llandovery-Tarannon) above.

In the present state of our knowledge a few notes on the dominant characters of the fossils may be of use to future students of these beds.

In Lakeland and South Wales the abundance and variety of Cystidea is very noteworthy. These fossils are specially found in the *Staurocephalus* Limestone of the northern area and in the Sholeshook Limestone of the Principality. Cystidea of course have a long range, but some of those found in the Ashgillian Limestones are probably characteristic forms. They appear, however, to be local; for example, I am not aware of any record of these organisms in the Desertcreate Beds.

It has been noted above that *Strophomena* (?) *siluriana* is characteristic of the Ashgillian Beds of the North of England. It is still doubtful if this form and *Orthis hirnantensis* of the Hirnant Limestone are specifically distinct. At present we are only able to use the so-called *Strophomena* locally.

The Slade Beds of Haverfordwest are often crowded with *Phyllopora Hisingeri*. The occurrence of this form in the upper part of the Ashgill Beds of Backside Beck, near Sedbergh, is of significance. The latter beds are worthy of more careful examination.[1]

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[1] See Marr & Nicholson on "The Stockdale Shales": Q.J.G.S., vol. xliv, p. 700.

The trilobites have up to the present received most attention. By means of these Crustaceans we can most readily separate the Ashgillian Beds from those of Caradocian and Valentian ages.

The occurrence of *Staurocephalus* in the lower part of the Ashgillian Series and of *Dalmannites mucronatus* in the upper part (and also in the lower) has frequently been noted. A few remarks upon each of these forms will be useful.

The term *Staurocephalus* Beds was first applied to rocks belonging to the Ashgillian age in Sweden and subsequently in Britain. The Swedish form is *Staurocephalus clavifrons*, Ang. *Staurocephalus globiceps*, Portl., is probably identical with the Swedish form. Lastly, Salter (Mon. Pal. Tril., pl. vii) figures a form from Rhiwlas as *Staurocephalus Murchisoni*, Barr. It may be noted that Barrande's type form is from beds of Ludlow age. It is doubtful whether even the British Wenlock forms which are referred to this species are correctly assigned, and there are grave doubts as to the identity of the Bohemian and Rhiwlas forms. The Ashgillian *Staurocephali* require careful study, and the three forms above noted will probably prove to be identical or closely allied, and separable from the Wenlock and Ludlow fossils.

The genus, if found in Caradoc rocks, is extremely rare therein. It is also far from common in rocks of Valentian age, and its wide distribution in the Ashgillian Beds is distinctly noteworthy.

Dalmannites mucronatus, Ang., is particularly abundant in beds of Ashgillian age, and is very useful when separating them from the Caradocian deposits, in which, so far as I am aware, it has not been found. On the other hand, it passes up into the Valentian rocks, both in Britain and in Scandinavia, and forms one of the few connecting links of the Ordovician and Silurian faunas.

This form requires study. Angelin describes two species, namely, *Dalmannites mucronatus*, which in Sweden is a Valentian form, and *D. eucentra*, which occurs in the equivalents of the Ashgill Shales. Salter also separated the North of England form from the type *mucronatus* as var. *appendiculatus*. Later writers have referred all to *mucronatus*, and if the Ashgillian and Valentian forms be distinct they are certainly closely allied.

While speaking of the *Phacopes*, we may note that the group *Chasmops*, so abundant in rocks of Caradocian age, appears to be absent from the Ashgillian Beds, and that the group *Phacops* proper, which is found abundantly in the overlying Valentian rocks, has also never been recorded from beds of Ashgillian age.

Turning now to the genus *Trinucleus*, we find that this form, so abundant in all Ordovician rocks, is well represented in the highest Ashgillian Series. The sudden disappearance of this form at the top of the Ashgillian Beds is one of the most important means of separating these from the Lower Valentian (Llandovery) Beds. It is true that *Trinucleus* has been more than once recorded in beds of Llandovery age, but even if these records be correct the genus is *extremely* rare in them. Let us for a moment notice these records.

In Cat. Camb. and Sil. Foss., p. 78, Salter records *T. concentricus* from the Lower Llandovery of Pen-y-craig. I find the actual specimen now placed among the Caradocian fossils in the Sedgwick Museum, on whose authority I cannot say, but Professor Hughes, who knows the district well, assures me that at the time of this determination considerable confusion existed as to the age of the various beds there.

There are various references to the occurrence of *Trinucleus* in both Lower and Upper Llandovery rocks in the Mem. Geol. Survey, vol. iii (3rd edition, 1881), but the information given is of the vaguest, and I cannot help suspecting mistakes.

In 1877 Professor Harkness & Nicholson gave in the Quarterly Journal of the Geological Society a list of trilobites from the Stockdale Shales. In this was included *Trinucleus fimbriatus*, a determination which Professor Nicholson subsequently admitted to be founded on error, and accordingly the species was not recorded in the later paper on those shales by Professor Nicholson and myself.

On the Continent one example of *Trinucleus Wahlenbergi* is recorded in Kjerulf's "Veiviser" from stage 5 (of Llandovery age). It occurred in a nodule, and may possibly be derivative.

In any case the extreme rarity of the genus in the Valentian rocks is in marked contrast to its abundance in even the highest (Slade) stage of the Ashgillian Beds, though it must not be supposed that *Trinucleus* is common or even represented in all Ashgillian strata; it is, for example, distinctly rare in those of most localities in the North of England.

Of trilobite species which, so far as I know, are confined to Ashgillian rocks, I may mention *Encrinurus sex-costatus*, *Cheirurus octolobatus*, *Cyphoniscus socialis*, *Remopleurides longicostatus*, and *Ampyx tumidus*. There are many others which have hitherto been found in one or two localities only.

Several forms which occur rarely in Caradoc rocks are more abundant in the Ashgillian strata, as *Acaste Brongniarti*, *Agnostus tumidus*, and *Phillipsinella parabola*.

The graptolites found at Desertcreate will enable us to compare those rocks with their graptolite equivalents in the Moffat area. As, however, the work is being done by Mr. Fearnsides and his colleagues, we must await the publication of their full results.

The following lists of fossils will be useful to students of the Ashgillian rocks at home and abroad:—

Mem. Geol. Survey, Catalogue of Lower Palæozoic Fossils in the Museum of Practical Geology (1878). In this list the specimens recorded as from "Rhiwlas" are, I believe, in all cases from the *Staurocephalus* Limestone. The various papers alluded to above mostly have fossil lists. In the paper by myself on "The Coniston Limestone," the Keisley species, as above stated, belong to the Ashgillian, and not, as there recorded, to the Caradocian. A full list of the Keisley fauna is given in Mr. Reed's papers on the Keisley Limestone. The South Welsh forms are recorded in the paper by Mr. Roberts and myself, and in that by Mr. Evans. Irish forms of Ashgillian age are noticed in Messrs. Gardiner & Reynolds' papers, and in the brief notice of the Pomeroy Beds by Mr. Fearnsides. A few Scotch forms are mentioned in Prof. Lapworth's Girvan paper.

In Scandinavia we find records of fossils from the Brachiopod-schists in Linnarsson's account of the Cambrian and Silurian Beds of Westrogothia (K. Svensk. Vetensk.-Akad. Förhandl., Bd. viii, No. 2; in this paper some of the forms are apparently from the Upper Brachiopod schists, of Llandovery age); and also in Tullberg's papers on the Scanian graptolites (Svensk. Geol. Undersökn, series C, No. 50, p. 17), in the zones of *Staurocephalus clavifrons* and *Phacops mucronata.* Records of fossils of the *Leptæna* Limestone will be found in various papers by Törnquist, especially in a paper on the Palæozoic rocks of the Siljan district (Öfvers. af k. Vetensk.-Akad. Förhandl., 1874); and another on the trilobite fauna of the Siljan district (Sver. Geol. Undersökn, 1884); also in Angelin's "Palæontologia Scandinavica" and in Lindström's "Fragmenta Silurica."

A list of Russian fossils from Stage F will be found in the first part of Schmidt's "Revision der Ostbaltischen Silurischen Trilobiten" (Mem. l'Acad. Imp. des Sciences de St. Pétersbourg, 1881).

The above list is no doubt far from complete, but the student may obtain from a perusal of these papers a good idea of the varied character of the Ashgillian fauna.

IV. THE BASE AND SUMMIT OF THE ASHGILLIAN SERIES.

(1) *Base.* In South Wales, where the Ashgillian succession is so well shown, the line of demarcation between the Robeston Wathen Limestone of Caradocian age and the Ashgillian Sholeshook Limestone is usually easily determinable. Although each is a limestone, they are fairly readily separable by lithological characters, and the change in fauna is very marked. Similarly, in the Lake District the change from the Caradocian Sleddale Limestone and the Ashgillian *Staurocephalus* Limestone is usually well marked, though it is possible that in the fossil lists some forms referred to the Caradocian division really belong to that of the Ashgillian. In the Cross Fell Inlier the difference between the equivalent of the Sleddale Group (Dufton Shales) and the Ashgillian Limestones is most obvious. The exact base of the Ashgillian group at Girvan yet remains to be fixed, and, as before stated, much remains to be done in North Wales.

(2) *Summit.* The line of demarcation between the Ashgillian and Valentian is usually less readily determinable than that at the base of the former series. The difficulty was admitted by Salter when he bracketed the Lower Llandovery and Upper Bala Groups (Cat. Camb. and Sil. Foss.).

There are two causes of difficulty; one the frequent similarity between the Ashgillian and Llandovery rocks, and the other the difference of opinion as to what line should be taken as marking the top of the Ashgillian. With regard to the former, the Ashgillian and Llandovery Beds of the Haverfordwest region have a striking similarity, though separated by a conglomerate, and in Scandinavia the line of demarcation must be drawn in the middle of the Brachiopod-schists.

I believe that the fossils will usually furnish a ready means of distinction. The practical disappearance of *Trinucleus* at the top of the Ashgillian has already been noted, and, so far as I know, the genera *Nidulites*, *Phacops* (proper), and *Stricklandinia* are not found below the Lower Llandovery.

The difference of opinion as to what line should be taken as separating the Ordovician from the Silurian requires fuller consideration. Professor Lapworth in the Moffat district places the lowest zone of the Birkhill Shales, that of *Diplograptus* (*Cephalograptus*) *acuminatus*, in the Silurian, while Tullberg assigns the corresponding zone in Scania to the Ordovician, because it, like the Scotch zone, has no *Monograpti*. Lithologically and palæontologically, however, it seems to be more closely related to the overlying beds than to those beneath it, and I would follow Lapworth in assigning it to the Silurian.

In North Wales the question is not so easy. The Hirnant Limestone is not a richly fossiliferous deposit, its most frequent fossil being *Orthis hirnantensis*. Salter, as we have seen, referred it to the Upper Bala, while Professor Hughes has maintained that two deposits have been referred to this division, the lower of which is Ashgillian and the upper Llandovery. The question remains to be settled.

It may be remarked that the Llandovery Beds of Wales and the Welsh borders still require much work. Professor Hughes has separated the fossils of the Upper and Lower Llandovery Beds of the typical area, and his collections are preserved in the Sedgwick Museum, but his observations require extension in surrounding areas.

My objects in this paper have been to show that the Ashgillian Beds form a group sufficiently important to be separated as a series from the beds of the Caradocian Series below; to prove that the term Upper Bala applied by Salter was too vaguely defined to stand (even were the term not objectionable on other grounds), and that therefore another term is required, that of Ashgillian being adopted because the term "Ashgill Beds" used by Salter for his Upper Bala Beds in the Lake District was applied to a definite group well defined by him; lastly, to indicate to future workers the lines on which to proceed in giving us what we greatly require, a monograph upon the stratigraphy and palæontology of this important series.

TABLE OF THE ASHGILLIAN STRATA OF THE BRITISH ISLES.

SOUTH WALES.	NORTH WALES.	N. OF ENGLAND.	GIRVAN.	IRELAND.
Slade Beds.	Hirnant Limestone ?	*Phyllopora*-Beds of Backside Beck, Sedbergh ?	?	?
Redhill Beds.	*Mucronatus*-Beds of Conway. = Shales near Maeshir ?	Ashgill Shales.	Ladyburn Shales.	Tirnaskea Beds.
Sholeshook Limestone.	Rhiwlas Limestone.	*Staurocephalus*-Limestone (with Keisley Limestone).	Starfish Bed.	Killey Bridge and Bardahessiag Beds. =Chair of Kildare Limestone. =Portraine Limestone.

III.—NOTES ON THE FAUNAL SUCCESSION IN THE CARBONIFEROUS LIMESTONE OF WESTMORELAND AND NEIGHBOURING PORTIONS OF LANCASHIRE AND YORKSHIRE.

By E. J. GARWOOD, M.A., Sec. G.S.,
Professor of Geology in University College, London.

IN August last, at the meeting of the British Association at York, I gave a general account of the zonal succession of the Carboniferous Limestone as developed in Westmoreland and North Lancashire, and I instituted a comparison with beds of a similar age in the Ingleborough and North Pennine districts.

In response to a request made at the meeting, I drew up a table in which a provisional correlation was attempted with the zones of the Avonian Succession. I had not then, however, had the opportunity of consulting Dr. Vaughan regarding his most recent conclusion, the correlation with the Avonian Succession being based on the tables accompanying his paper and that of Mr. Sibley on the Mendip area.

I hope shortly to describe the Northern Succession more fully, but meanwhile I take the opportunity afforded by the courtesy of the Editor of the GEOLOGICAL MAGAZINE to bring forward the problems involved in any correlation of the northern areas more fully than could be done in the short abstract published by the Association, and to revise the attempted correlation of the lower beds with Dr. Vaughan's zones.

The key to the northern area lies in the *Michelinea megastoma* bed as developed in the Arnside section, where it contains a rich fauna. This bed, together with the underlying Meathop Limestones, I have long considered to lie near the base of the succession in the north, but its relation to the Shap and Ravenstonedale Limestones and the overlying Ashfell Beds was not absolutely clear, on account of the absence of the *Michelinea* bed from the eastern exposures. The lowest bed at Arnside contains amongst others the following characteristic forms:—

- *Michelinea megastoma.*
- *Zaphrentis* aff. *cornucopiæ.*
- *Caninia cylindrica.*
- *Productus* aff. *punctatus.*
- *Orthotetes crenistria.*
- *Athyris expansa.*
- *Chonetes* cf. *comoides.*

In addition a very characteristic *Cyathophyllum* occurs in which the septa show a marked Zaphrentid type of grouping, and a new species of *Clisiophyllum*, which Dr. Vaughan has since told me he is about to describe from the basement bed at Horton, where it also occurs.

Dr. Vaughan agrees with me that this fauna points to a position near the top of his C zone in the Bristol area. No Lithostrotions occur in the *Chonetes* bed, but immediately above, in the overlying Black Limestone of Blackstone Point, they occur in abundance, together with *Diphyphyllum* and Campophyllids, and I therefore take the Blackstone Point Beds as representing the base of S_1.

These beds can be traced for a mile or two in an easterly direction, and reappear again near the base of the Scout Scar section, both in the Brigsteer and Underbarrow road cuttings (Barrowfield Beds of the table).

In the Brigsteer section occur all the species characteristic of the Arnside Beds, including the giant *Chonetes* cf. *comoides* and unusually large specimens of *Orthotetes crenistria*, neither of which occurs above this horizon in any section I have examined in the north. Indeed, the greater part of the fauna of the bed is strictly limited to this horizon, and nearly the same association occurs at the base of the Ingleborough succession,[1] and undoubtedly represents the same horizon.

Any beds, therefore, below these are of special interest, as they carry us well down into C or lower. Such beds occur at Low Meathop, opposite Arnside, and at Crag Mollet in the Brigsteer section; in both places they consist of purple dolomitic limestone, and contain fine silicified specimens of *Syringopora* (cf. *reticulata*) and small Cyathophyllids and Seminulas, while at the base at Crag Mollet occurs a bed marked by clusters of *Diphyphyllum pseudo-vermiculare* (McCoy).

If this Diphyphyllid *Lithostrotion* is to be considered typical of (S), then the whole of the Arnside Beds and the Horton Beds will have to be included in (S) also. It is possible, however, that we have here the forerunner of the *Lithostrotion* fauna, which becomes so characteristic of the *Seminula* zone above.

In the Shap and Ravenstonedale district further east the *megastoma* bed is absent, but the same purple dolomitized limestones with *Syringopora* occur towards the base, though they are here much thicker and include lower beds than any found at Kendal or Meathop, so that at Ravenstonedale we probably have the lowest beds found anywhere in the district. The absence of the *megastoma* bed makes the sequence rather more difficult to subdivide, but as the result of many years' work in the district I have come to the conclusion that this bed is represented in the Shap area by the sandstone near the base of the Ashfell series.

The evidence on which I rely is as follows:—At Brigsteer, immediately beneath the *Michelinea* bed, we have the Crag Mollet Bed full of *Diphyphyllum pseudo-vermiculare*, which, as far as I am aware, has not been found elsewhere at any higher horizon. The same form occurs abundantly near the top of the Shap-Ravenstonedale Limestone near the base of the Ashfell group, so that the latter should include the *megastoma* bed.

Again, the base of the Knipe Scar or Melmerby Limestone, resting on the Ashfell Beds, is crowded with silicified specimens of *Cyrtina carbonaria*, a form characteristic in the western area of the base of the upper *Seminula* zone[2]; furthermore, in the Shap section at the base of the Ashfell series, occurs a thin layer enclosing remains of *Camarophoria isorhyncha*, a form characteristic of the very base of the lower *Seminula* zone.[3]

Lastly, at Kettlewall, on the east side of the Kendal outlier, we have an epitome of the sequence in both areas. Here the *megastoma* bed, very much reduced in thickness, is overlain a few feet above by a limestone containing *Cyrtina carbonaria* (the locality whence the type-specimens figured by McCoy and Davidson were obtained), and it has already been shown that the bed containing *Diphyphyllum pseudo-vermiculare* underlies the *megastoma* bed on the west side of this outlier. It seems, therefore, practically certain that the Ashfell Sandstone, with its included limestones, represents the whole of the lower *Seminula* zone, and that the *megastoma* bed is represented by the very top of the Shap-Ravenstonedale limestone or the base of the Ashfell group.

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[1] See Cosmo Johns & Vaughan: GEOL. MAG., 1906.
[2] Dr. Vaughan: Q.J.G.S., vol. lxi, p. 254, footnote.
[3] T. F. Sibley: op. cit., vol. lxii, p. 376.

This fact is of great interest outside the question of local correlation of these northern exposures, as it shows that in the northern area we have a marked upheaval producing shallow-water conditions at the top of the Tournasian and base of the Viséan times, similar to that recorded from the south-west province, the Ingleborough district, and elsewhere, resulting possibly even in contemporaneous erosion in some places.

With regard to the age of the lowest beds at Shap Abbey and Ravenstonedale, it is difficult to speak with certainty here. I was at first inclined to place the lowest beds at Ravenstonedale as low as Dr. Vaughan's *Cleistopora* zone, on account of the occurrence of a flat encrusting coral resembling *Cleistopora*, but Dr. Vaughan informs me this is not his typical form, and as this may not be a *Cleistopora* I have taken *Athyris glabristria* and *Spirifer* aff. *clathratus*[1] as characteristic forms for these lower beds. The latter occurs throughout the lowest beds,[2] but is specially abundant at the base, the former being plentiful near the bottom of the Shap-Ravenstonedale Limestone, while this limestone, as stated above, is everywhere characterized by a fine *Syringopora*. As *Spirifer* aff. *clathratus* occurs throughout Z and K in the Bristol area, and as corals also occur, which, though badly preserved, appear to resemble *Zaphrentis Phillipsii*, I have provisionally assigned the lowest beds in the Ravenstonedale district to the *Zaphrentis* zone of the Avon district.

The Shap Abbey Beds do not appear to include these lowest beds, and although they are rich in *Athyris glabristria* and also contain a species of *Spiriferina* and Modioliform lamellibranchs, they will probably not be found to represent beds much below the base of the C zone of Dr. Vaughan.

The correlation of the higher beds in the table does not call for much comment here. The presence of *Lonsdaleia floriformis* and *Petalaxis Portlocki* at Humphrey Head together with *Dibunophyllum* aff. ψ at Grange, shows, that the upper *Dibunophyllum* beds are represented in the western extension of the district, and that a fault occupies the Kent estuary, bringing the lowest beds at Meathop against the highest beds at Grange. The same association of forms at Outscar, Bampton, and elsewhere, shows, that these upper beds are also present in the Shap district, and the beds below contain a typical lower *Dibunophyllum* fauna with *Cyathophyllum Murchisoni* and *Alveolites septosus* and characteristic *Producti*.

[1] Kindly determined for me by Dr. Vaughan.
[2] Lower Limestone Shales of the Government Map.

Dr. Vaughan's Zones.	SUB-ZONES SUGGESTED FOR WESTMORELAND AND WEST YORKSHIRE.	SHAP DISTRICT.	RAVENSTONEDALE.	ARNSIDE GRANGE DISTRICT.	KENDAL.	NORTHERN PENNINES.	INGLEBOROUGH AND PENYGENT.
D₃	*Productus* cf. *Edelburgense.*	...	...	...	...	...	Upper Scar Limestone.
D₂	*Dibunophyllum* in stage ψ. *Productus latissimus.*	...	...	Kent's Channel Beds.	...	Great limestone, Teesdale and Weardale.	Limestone of Hull Pot Gill.
	Productus giganteus. *Lonsdaleia floriformis.*	Outscar Beds. Bampton, etc.	(?)	Humphrey Head, east side. *Petalaxis Portlocki.* *Cyathophyll. regium.*	(?)	*P. giganteus* beds. 'Scar limestone.' *Lonsdaleia* bed. Hilton Beck. Hardraw Scar, etc., etc.	Hunt Pot Beds, with *Dibunophyllum* aff. ψ. *Spiriferina* cf. *octoplicata.*
D₁	*Dibunophyllum* in stage θ. *Cyathophyllum Murchisoni.*	Upper Knipe Scar. Up. Hardendale Nab. Upper Orton Scar.	(?)	Humphrey Head, west side. Eggerslack Beds.	Serpentine Walks Limestone.	Upper Melmerby Limestone of Middle Tongue Crag, etc.	Upper Ingleton (White Scars) Beds. *Dibunophyllum* aff. θ.
S₂	*Productus corrugato-hemisphericus.* *Chonetes papilionaceus.*	Lower Hardendale Beds.	? Waitby Beds.	Arnside Knott and Wharton Crag.	Upper Scout Scar Beds.	Lower Melmerby Limestone. Long Fell. Musgrave Scar, etc.	*Chonetes papilionaceus* beds, White Scars, Moughton & Horton Sc.
	Nematophyllum minus. *Cyrtina carbonaria.*	? Ashfell Sandstone.	Smardale Fell. *Cyrtina* beds. Upper Ashfell Sandstone.	Hampfield Beds. Lower Wharton Scar. Far Arnside, Middlebarrow, and Sandside Quarries.	Lower Scout Scar Beds. Kendal Fell. Kettlewell Quar. *Cyrtina* bed.	? Bituminous limestone beds of Roman Fell.	*Bellerophon* beds of Horton, Coombe and Craven Quarries, with *Nematophyllum minus.*
S₁ C₂	*Michelinea megastoma.* *Caninia cylindrica.* *Chonetes* cf. *comoides.*	?Water's Farm Series. *Camarophoria isorhyncha* bed. ?Docker Beck Oolites. ? Gastropod bed.	? Lower Ashfell Beds. ? Upper Ravenstonedale Limestone.	Blackstone Pt. Beds. Arnside Beds, with *Z. cornucopiæ* and *Chonetes* cf. *comoides.*	Barrowfield Beds Kettlewell Cave Beds.	Roman Fell Sandstones, with *Syringothyris* cf. *cuspidata.*	? *Paludina* shale, Horton in Ribblesdale basement bed, Ingletondale, etc., with *Michelinea* and *Caninia.*
?C₁	*Syringopora* cf. *reticulata.* *Diphyphyllum pseudo-vermiculare.* *Productus* cf. *burlingtonensis.*	*Diphyphyllum* bed. Raisbeck, etc. *Spiriferina* shale. Bryozoa bed.	Middle Ravenstonedale Limestone.	Meathop Fell Beds.	*Cyathophyllum* cf. *Murchisoni* bed. Crag Mollet *Diphyph'm* bed.		
? Z	*Athyris glabristria.* *Spirifer clathratus.*	Basement conglomerate.	Stone Gill Beds. Basement beds Pinskey Gill, etc.				

In the Horton district we appear to have a normal succession. On Ingleborough, above the *Caninia* basement bed S_2 is represented by the *Bellerophon* bed with *Nematophyllum minus*, and is in all respects similar to the same zone on Scout Scar, Hampsfield Fell, etc. Above these, beds rich in *Chonetes papilionaceus*, *Lithostrotion Portlocki*, and *Alveolites septosa* succeed, and corals allied to *Dibunophyllum* ϕ are not uncommon still higher with characteristic *Producti*. But I do not know of the occurrence of *Lonsdaleia floriformis* or *Productus giganteus* on Ingleborough. On Penygent, however, at Hunt Pot, we have a rich fauna of upper *Dibunophyllum* age containing, beside the typical *Productus giganteus*, *Lonsdaleia floriformis*, *Dibunophyllum* aff. ψ, *Lithostrotion junceum*, etc. In the lower shale band a *Spiriferina* closely related to *octoplicata* is common, and Dr. Vaughan tells me that he has lately traced Sowerby's type-specimen of *Spiriferina octoplicata* to an horizon which appears to be D_2, the identical horizon of the Hunt Pot Beds.

The bed above this on Penygent is frequently crowded with *Productus latissimus* and thick reefs of *Dibunophyllum* in the ψ stage, a form which appears to be larger and longer than the typical examples. This bed is represented on Ingleborough by the cement-stone bed seen in the swallowhole dedicated in the Ordnance map to Tatham's wife, and is also found at Riblehead. The same zone occurs in the Wensley Dale district at the top of the Hardraw Scar Limestone, while the bottom of that bed is full of typical *Productus giganteus*.

The highest zone in the district, that contained in the Upper Scar Limestone, shows a further modification of the giant *Producti* to a form which, some years ago, I tentatively referred to the variety *Edelburgense*.[1]

IV.—THE ROCKS OF NORTHERN GUERNSEY.

By JOHN PARKINSON.

Introduction.

IN a communication to the Geological Society in 1900 I had occasion to compare the rocks of the south-eastern coast of Jersey with the hornblende gabbro, diorites, and granites of Northern Guernsey; and to point out that in general terms the petrographical types of the two islands bore a close resemblance to each other, group for group, in sequence and general relations. Since work abroad renders it improbable that I shall be able to devote much additional time to this subject, the following notes are given as a possible aid to future observers.

The very valuable work of the Rev. Edwin Hill[2] in this island renders superfluous any lengthy note on general characters; suffice it to say that the southern part of the island consists of gneiss with a few intrusive masses and dykes; the northern of diorites and intrusive granites, except for an oblong area on the eastern coast, between St. Peter's Port and St. Sampson's, which is composed of hornblende gabbro.

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[1] I here limit the term *giganteus* to the large coarse-ribbed forms found, as far as I am aware, only in the *Dibunophyllum* zone, and usually confined to the upper part of that zone.

[2] Quart. Journ. Geol. Soc., vol. xl (1884), p. 404 and map.

In the present paper the field evidence will be briefly reviewed, and reference made to the microscopic work only when necessary.

The subject can be divided into two parts—

(1) The hornblende gabbro.
(2) Sections on the northern and western coasts.

(1) THE HORNBLENDE GABBRO.

Detailed examination of the coast between St. Sampson's and St. Peter's Port resulted in the following conclusions:—

(*a*) A hornblende-labradorite rock, the former mineral more or less completely replacing augite, is characteristic. The rounded outlines of the ferromagnesian mineral give a spotted appearance to this rock, which may be considered as typical of the locality ('bird's-eye' of quarrymen). It varies remarkably, however, in the relative quantity of the distinctive minerals present, i.e., either felspar or ferromagnesian constituents may predominate; such alteration taking place, sometimes as a gradual change, sometimes as a more rapid alternation of parts, of the nature of banding, in which the constituents are equally distributed.[1] A common variation results in a fine-textured rock, more basic than the average, in which the hornblende is original and not secondary, elongated prisms predominating instead of a rounded poecilitic form of augite; and the mineral, as seen in a thin section, is almost opaque through the presence of opacite. A banded structure, the occurrence of less clear and well-defined streaks differing mineralogically from the surrounding rock, and the parallel arrangement of such a mineral as hornblende indicate fluxional movement, and give rise to the irregular approximation of varieties differing considerably in composition.

(*b*) Later dykes cut these rocks, and belong to at least two periods. The earlier are rich in hornblende; the later, often very abundant, consist almost entirely of felspar.

A thin section of the former shows that hornblende composes at least half the rock. It forms polygonal grains (average size ·009 inch, but frequently considerably larger, say ·03 inch), which approach to an ophitic structure through the earlier consolidation of the felspars, but have a tendency to gather into groups of grains to the entire exclusion of this mineral.

The more acid dykes show a strong tendency to follow the directions taken by the earlier system, with the result that a kind of composite dyke is produced. The variations in the hornblende gabbro go to show that a rock which forms a dyke in one place may in another pass gradually into one on the whole older which surrounds it. This close relationship is strongly borne in upon the observer. Especially noteworthy are the large elongated hornblendes in the felspar dykes, producing a close resemblance to the extreme felspathic variation of the 'bird's-eye.' The dimensions of the dykes exercise no influence on the dimensions of the hornblende.

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[1] See Professor Bonney's description: Quart. Journ. Geol. Soc., vol. xl (1884), p. 425. Mica is rare in these rocks.

A thin section cut from one of these shows that the characteristic mineral is obscured by secondary products, but such extinctions as can be seen indicate labradorite. The crystals are occasionally zoned. A few grains of apatite and ilmenite are the only accessory minerals.

The felspathic dykes contain also darker shreds and inclusions, sometimes clearly, sometimes indefinitely outlined, suggesting that a local absorption of derived fragments attended the intrusion. Occasionally a more definite arrangement of parts produces a rude banding. Thus in one instance the centre of such a dyke, cutting the ordinary 'bird's-eye,' was dark-coloured and close-grained, about 1½ inches across, and bordered by a narrow felspathic edge, not sharply marked off from the surrounding rock, while one or two identical felspathic patches were contained in the central part and were disposed roughly parallel with the direction of the dyke.

The dioritic rock, referred to under the heading Hornblende Gabbro (*a*), is found also as ill-defined fragments lying in a more felspathic matrix, which nevertheless contains a considerable quantity of hornblende. Other inclusions occur, petrologically inseparable from the hornblende dykes, while the rocks rich in felspar in which they lie are indistinguishable from the later dykes when these contain hornblende.

A note by the Rev. Edwin Hill and Professor T. G. Bonney on a banded specimen of 'long-grain' and felspathic rock from here, is of interest in this connection.[1] The inferences drawn as to the possible derivation of the hornblende from augite and the occurrence of biotite as a derivative from the former mineral are entirely in accord with my own work, as is also the conclusion that the rock "exhibits an imperfect mixture of two magmas" (p. 137). A slight difference in the physical state of either or both of the magmas may give rise on the one hand to a brecciation, on the other to interbanding.

Examination of Bordeaux Harbour and the shore between Hougue à la Perre and St. Peter's Port did not appear to me to warrant the conclusion that the hornblende gabbro was genetically distinct from the dioritic rocks to the north and south.

(2) SECTIONS ON THE NORTHERN AND WESTERN COASTS.

(*a*) *East Shore of Grande Havre.*—The quarry at the south-east angle of Grande Havre is excavated in a fine-grained mica diorite containing a little quartz. A thin section shows that the hornblende is intimately associated with biotite, which apparently replaces it, and forms a kind of matrix to the other minerals. A coarser rock consisting of plagioclase, some orthoclase, and a considerable quantity of quartz (sometimes a full third of the rock) is intrusive into it. The junction, which is not very clearly defined, is made apparent by the greater size of the felspars of the more acid rock, accompanied by the development of biotite to the exclusion of hornblende. The quartz has corroded the felspar. The more basic side of the junction consists of plagioclases varying from oligoclase to labradorite, usually with a more translucent border, a little quartz, a considerable quantity of brown mica in flakes up to ·028 inch across, and green hornblende taking the form of rounded polygonal grains. Further observation shows that the younger of the two varies greatly in composition, and, although usually containing hornblende and conspicuous crystals of biotite, yet the dark minerals may be locally absent or represented by a group of irregularly disposed and elongated hornblendes, always considerably larger than any of the other constituents. Naturally there are many minor variations. For example, a slab may consist of two slightly different rocks, distinguished principally by their relative amounts of hornblende; the less basic containing drawn-out patches of a finer textured and darker rock. Fluxional movement is indicated by bands of different mineral composition, which occasionally are traceable for eight or ten feet. The almost invariable presence of quartz and the common occurrence of large ragged plates of biotite distinguish these rocks at once from the hornblende gabbro of the east coast.

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[1] Quart. Journ. Geol. Soc., vol. xlviii (1892), p. 135.

(*b*) *The East Coast North of the Hornblende Gabbro.*—At Hommet Bennest, to the north of Bordeaux Harbour, we find a close-grained diorite weathering grey through the presence of felspar, which predominates slightly over the hornblende. This rock is veined and streaked by one still more felspathic, which contains a ferromagnesian mineral. The older of the two rocks consists of a felspar too opaque for determination, slightly earlier in consolidation than the hornblende, an altered mica, and a little magnetite. Small patches of quartz and a translucent felspar are found here and there. Hornblende bordering these patches assumes the form of an actinolitic fringe. Comparison with other slides suggests these patches are the early stages of a permeation by a more acid magma.

(*c*) *From Vale Castle to Fort Norman.*—A uniform blue-coloured quartz-diorite with no clear signs of veining or intrusion is quarried along the shore to the north of Vale Castle. This is a variety of the older rock of Grande Havre Quarry—a quartz-mica diorite. We meet with a very similar rock to the west of Lancresse Common, but differing in being richer in quartz and biotite. In both slides the felspars are often zoned, the outer border more translucent than the centre, while the higher extinction angle and irregular outline of the central part suggests the corrosion of a basic species. A little more than half-way between the Castle and the Fort the diorite is cut by a lighter-coloured and coarser rock, containing, however, some quantity of hornblende, which locally assumes an elongated outline.

The character of the intrusion is irregular and streaky. On a jutting headland to the south of the Fort is a fine-grained diorite like that of Hommet Bennest, consisting of hornblende and felspar, the latter slightly the earlier in crystallization, some is untwinned, but plagioclases occur varying from oligoclase to labradorite. It is broken by veins or dykes of a felspathic rock speckled with hornblende. Occasionally dykes, about an inch wide, can be traced for five or six feet. A thin section across the junction exhibits the following association: a fine-grained quartz-free hornblende plagioclase rock on the one side, a coarser quartz hornblende felspar rock on the other.

The latter is the intruder, but the boundary between the two is quite indefinite, partly no doubt owing to the opaque state of the felspars, which hinders a precise determination. In the older rocks the hornblende formed after the plagioclase, and is locally replaced by biotite; in the younger the quartz is inconspicuous, and plagioclase is plentiful (oligoclase to labradorite), with a tendency towards idiomorphism.

A striking contrast exists between this rock and the intrusive member at Grande Havre. Not only is the latter coarser, but its plentiful quartz and biotite distinguish it at once from any rock on the east coast, while the former is not unlike the late felspathic dykes cutting the hornblende gabbro.

(*d*) *East and South of Fort Marchant.*—At the southern end of the Fort Marchant peninsula the diorite contains rounded hornblendes, resembling the spots on a trout, with which is associated a variety containing the same mineral as elongated prisms. Both are veined by a third rock, richer in felspar (some orthoclase and acid plagioclases), and containing a little quartz, some biotite, and green hornblende.

This assemblage, for the members cannot well be separated, passes into a rock which, although poorly developed, is identical with the 'bird's-eye' of the shore to the north of St. Peter's Port. It contains segregations of hornblende and locally more felspathic patches containing hornblendes, connected in some instances with irregular veins.

Similar phenomena of variation, and intrusion which may be called intermingling, are abundant elsewhere in the northern part of the island. Thus we find evidences of a brecciation more or less sharply defined all over the quarries near the Saumerez Monument.

The younger rock is of a more granitic composition than that into which it has forced its way, and when pure, i e. unassociated with fragments, seemingly not rich in either black mica or hornblende. The older rock is a quartz-diorite, on the whole uniform in texture, but which contains more basic fragments, having edges sometimes well defined, sometimes passing into the surrounding rock in a cloudy way, a zone half-an-inch or so wide being common to both.

Locally the invading rock is distinctly streaky; the whole suggesting that the older member was in a state of imperfect consolidation at the time of the intrusion of the more acid magma, and that some absorption took place.

The hornblende-felspar rocks south of Fort Norman and from Hommet Bennest are essentially the same as the more basic parts of rocks from the west of Fort Doyle and the black dykes cutting the 'bird's-eye' of the St. Sampson's area.

Conclusions.

1. That in the northern half of Guernsey we have a series of igneous rocks, which, with the probable exception of some granites on the west coast, are related to each other as the products of differentiation of a single magma.

2. Some evidence exists for a progressive increase in acidity in going north and west.

V.—ON A NEW BRACHYUROUS CRUSTACEAN FROM THE "*CLYPEUS*-GRIT" (INFERIOR OOLITE) OF THE COTTESWOLD HILLS.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.,
late Keeper of Geology, British Museum (Natural History).

IN November last Mr. L. Richardson, of Cheltenham, very kindly sent me (with other fossils for inspection and determination) the carapace of a small Crustacean from the "*Clypeus*-Grit" of the Cotteswolds, which had been picked up and given him by Mr. C. L. Walton. As Mr. Richardson anticipated, the species proves to be new to this country, and I readily obtained his permission to describe the same.

Forty years ago (in November, 1866) I communicated to the Geological Society of London an account of the then oldest known British crab, *Palæinachus longipes*, from the Forest Marble of Malmesbury, Wilts (see Quart. Journ. Geol. Soc., vol. xxii (1866), pp. 493–494, pl. xxiv, fig. 1), obtained by the late Wm. Buy, of Christian Malford, the well-known collector of Oxford Clay and Oolitic fossils. This form (which has the limbs preserved and still attached to the carapace) agrees closely with the living 'Spider-crabs' of the genus *Inachus*, and differs generically from the newly-discovered fossil. Two years later, in 1868, I described an Oolitic crab from the "Stonesfield Slate," of which three specimens (two of them very imperfect and one a nearly perfect carapace) are known. It was named by me *Prosopon mammillatum* (see GEOL. MAG., 1868, p. 1, Pl. I, Figs. 2, 2*a*). This crab carried the Brachyurous Decapods considerably further back, chronologically, than the Forest Marble example, which in its turn has now been surpassed in age by the newly-discovered specimen from the "*Clypeus*-Grit" of the Inferior Oolite. The Stonesfield crab, *Prosopon mammillatum*, although near generically to the new crab, is twice its size, and differs in several important details from it—especially in the frontal region of the carapace—but the absence of limbs and other ventral and oral structures renders strict determination rather unsatisfactory.

Fortunately Professors Reuss[1] and Herman von Meyer[2] have described and figured three genera and twenty-nine species of small crab carapaces, some fifteen of which have been refigured by me in Salter & Woodward's Chart of Fossil Crustacea.[3] These are from the Upper White Jura of Oerlinger Thal and other localities in Germany, also one from the Lower Oolite, three from the Coral Rag, and one from the Neocomian. In my paper in 1868 (GEOL. MAG., January, pp. 3–4), I endeavoured to separate von Meyer's Oolitic species of the genus *Prosopon*, and referred eleven of them with some hesitation to Bell's genus *Plagiophthalmus* (op. cit., p. 4). Of the remaining species—still retained by me in the genus *Prosopon*—those *most nearly* related to the new species from the "*Clypeus*-Grit" are *P. marginatum*, *P. grande*, *P. excisum*, and *P. lingulatum*. To these also most probably belong *P. elongatum* and *P. sublæve*.

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[1] Sitzungsb. k.k. Akad. d. Wiss. in Wien, xxxi, 1858.

[2] Mon. Prosoponidæ: Palæontographica, 1859–61, Bd. vii, p. 183, t. xxiii (Cassel).

[3] Catalogue and Chart Fossil Crustacea, 1865, figs. 1–15.

Subclass **MALACOSTRACA.**

Order 1. PODOPHTHALMA.

Suborder 1. BRACHYURA.

PROSOPON RICHARDSONI, H. Woodward, sp. nov. (Fig. 1.)

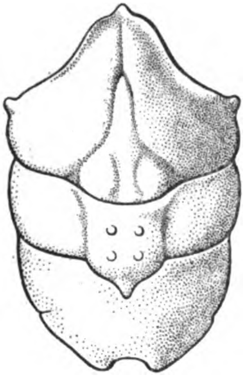

FIG. 1.—*Prosopon Richardsoni*, H. Woodw., sp. nov. Enlarged 2½ times nat. size. *Clypeus*-Grit, Inferior Oolite: South Cotteswolds. From the collection of Mr. Linsdall Richardson, F.G.S., of Cheltenham.

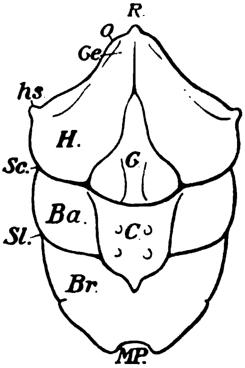

FIG. 2.—Outline key-figure to regions of carapace of *Prosopon Richardsoni*, H. W. *R.* rostrum; *O.* orbit; *hs.* hepatic spine; *Sc.* cervical furrow; *Sl.* lateral furrow; *MP.* posterior margin; *Ge.* epigastric lobe; *H.* hepatic region; *G.* gastric lobe; *C.* cardiac region; *Br.* branchial region; *Ba.* epibranchial lobe.

Diagnosis.—Carapace 21 mm. long by 15 mm. broad; frontal border broadly triangular, converging from the small hepatic spines (*hs.*) on the margin of the hepatic region (*H.*), where the width is 14 mm., to the obtusely prominent rostrum (*R.*), the frontal lateral margins being at first slightly concave, but becoming roundly convex as they join the rostrum, which is curved downwards at its point and furrowed along its centre. The orbits (*O.*) are not clearly to be made out. The gastric lobe (*G.*) lies in front of the cervical furrow (*Sc.*), and is 9 mm. broad at its base, its sides uniting to form with the base a triangle, 6 mm. long, terminating in a narrow acuminate point on the centre line of the carapace, where it merges in the rostral furrow. Immediately behind the gastric lobe is the cardiac region (*C.*), forming a shield-shaped escutcheon, 5 mm. broad in front, and terminating behind in a point 6 mm. from the cervical furrow on the central line and 5 mm. from the posterior margin (*MP.*); the lateral furrow (*Sl.*) crosses the carapace 4 mm. behind the cervical furrow (*Sc.*) and nearly parallel with it, but is interrupted by the shield-shaped cardiac escutcheon in the centre of the carapace, which is here 13 mm. broad; this furrow divides the branchial region into the epibranchial (*Ba.*) in front of (*Sl.*) and the branchial (*Br.*), which lies behind it. The carapace is rounded on its posterior-lateral border, and contracts to its posterior margin (*MP.*), which is 7 mm. in breadth and slightly emarginate. There is no evidence of any abdominal or caudal segments having been preserved, the ventral surface being firmly imbedded in very hard matrix.

There is evidence of the presence of four minute rounded tubercles on the surface of the cardiac region (*C.*), but as the carapace is decorticated it may have had other small papillæ upon its perfect test. No appendages of any kind are preserved.

Formation.—"*Clypeus*-Grit," Inferior Oolite.

Locality.—Tor Hill, near Wotton-under-Edge, South Cotteswolds.

Collection.—Mr. Linsdall Richardson, Cheltenham.

Remarks.—Although, thanks principally to the memoir of Herman von Meyer (1859), we are acquainted with quite a number of small carapaces of Crustacea of an oblong-oval form, from strata somewhat similar in character and age to that now under consideration, it is difficult without a knowledge of their appendages or the ventral surface of the carapace to place such forms more than approximately in their natural family, in relation to existing forms. There is, too, a strong tendency amongst these earlier Secondary Crustacea to present, in the same individuals, characters observed to be peculiar to distinct families in more modern times.

Thus it becomes difficult in the species of the genus *Prosopon*, which are only known by their carapaces, to refer them to the Maioidea (=Oxyrhyncha), the Leucosiidea (=Oxystomata), or to the Anomura (=Anomala), to each of which groups they seem to show synthetic relations.

In the evolution of the short-tailed crabs (Brachyura) one feature of great interest is the very noticeable change in the form of the carapace or cephalothorax. Thus in most modern crabs the body is broader than it is long, but in the earliest forms it is longer than broad. If the elongation of the cephalothorax is further accompanied by the exposure of the abdomen, which in most of the section Brachyura is quite small and carefully concealed beneath the cephalothorax, then the division between the short-tailed crabs (Brachyura) and the long-tailed lobsters and prawns (Macroura) disappears, and they become one group (the Decapoda).

No crabs are met with after the close of the Secondary period, but the Macroura are found in the Carboniferous rocks. These show evident signs of a further modification in structure, and we find many characters of the Schizopoda (the Squillidæ and Mysidæ) incorporated into the Macrouran Decapods of the Coal period. Thus the PODOPHTHALMA (stalk-eyed Crustacea), which exist now and in Oolitic times as *three* distinct suborders, were apparently represented in earlier post-Carboniferous times by two and in Carboniferous times by only *one* order. In point of fact, it is amongst these earlier individual forms of Arthropods that we should naturally expect to find those more generalized characters which occur in several distinct types only at a much later period in geological time.

I dedicate this little crab to Mr. Linsdall Richardson, who has devoted so much time to the unravelling of the stratigraphy of the Inferior Oolite of the South Cotteswolds of the Bath–Doulting district.

VI.—ON THE STRATIGRAPHICAL POSITION OF THE BEDS FROM WHICH *PROSOPON RICHARDSONI*, H. WOODWARD, WAS OBTAINED.

By L. RICHARDSON.

AS some months will elapse before the results of my investigations of the Inferior Oolite and contiguous deposits of the district between Doulting, near Shepton Mallet, and Stroud, are published, in order to show from which beds the *Prosopon* described by Dr. Henry Woodward, F.R.S., was probably obtained, it appears desirable to give an outline of certain of these results.

In the Doulting–Bath district the greatest number of subdivisions of the Inferior Oolite that can be recognised are six. They are, in ascending order, the Upper *Trigonia*-Grit, Dundry Freestone, Upper Coral-Bed (or "Coralline Beds"), Doulting Stone, *Anabacia*-Limestones, and certain rubbly beds, which, for want of a better term, may be called the "Rubbly Beds." In the whole of this Doulting–Bath district there is no Inferior-Oolite deposit of pre-*garantianæ* date. The deposit of *garantianæ* hemera, the Upper *Trigonia*-Grit, when traced from the neighbourhood of Bath towards the Mendip Hills is seen to transgress the outcrop edges of successively older beds. In a shaft on Timsbury Sleight, Timsbury, near Radstock, and also in the roadside section at Midford, it is seen to rest, non-sequentially of course, upon the Midford Sands. In the section by the railway bridge at Wellow it rests upon the Cephalopod-Bed of these parts, which, instead of coming *above* the "Sands," as does the Cephalopod-Bed of the Cotteswold Hills around Wotton-under-Edge, comes *below*. In the railway-cutting at Mells-Road Station the meagre representative of the Upper *Trigonia*-Grit reposes directly upon Liassic clays; but in the Vallis, near Frome, the "grit" has been overstepped by the Doulting Stone, which may be seen near Hapsford Mills, Elm, resting on a very much bored, planed, and oyster-covered surface of the Rhætic White Lias, and in the same neighbourhood upon an equally bored, planed, and oyster-covered surface of the Carboniferous Limestone.

Above the Upper *Trigonia*-Grit in the neighbourhood of Timsbury Sleight is a representative of the Dundry Freestone, and above that deposit the Upper Coral-Bed. The geographical extent of the freestone in this area is very restricted. It is represented in a section at English Combe, near Bath, but it is absent from the section at Midford, where the Upper Coral-Bed rests non-sequentially upon the Upper *Trigonia*-Grit. The Upper Coral-Bed, on the other hand, has a very considerable geographical extent. It is intermittent, it is true, but by means of its corals, brachiopods, and micro-organisms, it can be demonstrated that the well-known coral-beds of Midford, Rodborough Hill, and Worgen's Quarry, near Stroud, and the "Coralline Beds" of Dundry, are widely-separated patches of a contemporaneous deposit.

The remaining intervening deposits between the Upper *Trigonia*-Grit and the Fullers' Earth, namely, the Doulting Stone, *Anabacia*-Limestones, and Rubbly Beds, may collectively be called the "Doulting Beds." As far as I can see at present the beds known as the "*Clypeus*-Grit" in the Cheltenham District are equivalent to these Doulting

Beds. As far north even as Nailsworth, near Stroud, it is quite easy to identify the equivalents of the Doulting Stone and *Anabacia*-Limestones; but the Doulting Stone has become much more rubbly and fossiliferous. At Scar Hill, Nailsworth, the top-portion of the beds, which I correlate with the *Anabacia*-Limestones, are incipiently rubbly; and, indeed, as these Doulting Beds are traced farther north they become as a whole more rubbly, until in the *Clypeus*-Grit of Cleeve Hill, to the north-east of Cheltenham, it is not easy to identify the equivalents of the Doulting Stone, *Anabacia*-Limestones, and Rubbly Beds, although it can be done with a tolerable degree of certainty.

The quarry at Tor Hill may be divided, for descriptive purposes, into two portions—a lower, in which the massive oolitic limestones (which in this neighbourhood occur immediately below the Upper *Trigonia*-Grit) are worked; and an upper, in which the Upper *Trigonia*-Grit and rubble of higher beds was formerly quarried.

The carapace of the *Prosopon* given to me by Mr. C. L. Walton was picked up; it was not found *in situ*; but from the matrix I have no doubt whatever that it came from the Doulting Beds, and probably from that division of them which corresponds to the *Anabacia*-Limestones of the Doulting–Bath district. Unfortunately, however, only rubble of these beds caps the Tor-Hill section, but at Winner Hill—the next promontory to the south—there is a quarry in which a very satisfactory view of these top-beds is obtainable. The section is as follows:—

QUARRY AT WINNER HILL, NEAR WOTTON-UNDER-EDGE.

		Thickness in	
		ft.	in.
Rubbly Beds?	1. Limestone, coarsely oolitic, the edges of the flaggy pieces weathering into an oolitic 'marl'; *Terebratula globata*, Sow., *Rhynchonella* cf. *hampenensis*, S. Buckman, not uncommon in a bed at 2 feet above the base. The bottom-bed is more regular and has an even under-surface: seen 3 or 4 feet	3	6
Anabacia-Limestone equivalent.	2. Limestone, harder than the beds below, fine-grained matrix with large yellowish oolite-granules; maximum	1	1
	3. Limestones, yellowish, somewhat coarsely-oolitic in places	5	0
Doulting-Stone equivalent.	4. Limestone, greyish, fairly distinct bed on the south side of the quarry; no fossils recorded	0	11
	5. Limestone; *Ter. globata*, *Rhynchonella*, sp. indet., *Pecten* (*Syncyclonema*) aff. *demissus*, Phillips, *Serpula* sp. (same form as at Doulting)	0	5
	6. Limestone, massive, rubbly at the base, where *Ter. globata*, *Rhyn.* cf. *hampenensis* are not uncommon; *Acanthothyris spinosa* (Schloth.) ...	1	9
	7. Parting of brown shaly matter	0	0½
	8. Limestone, very hard, but rubbly at the centre; *Pecten* (*Syncyclonema*) aff. *demissus*, Phillips, *Ter. globata* (rare), *Acanthothyris spinosa*	3	0
	9. Brownish marly deposit, no micro-organisms seen (C. Upton): 0 to 2 inches	0	1

		ft.	in.
	10. Limestone, grey, oolitic, with a very uneven top: 4 to 8 inches	0	6
	11. Limestone, rubbly, slightly ironshot: 2 to 5 inches ..	0	3½
Upper *Trigonia*-Grit.	12. Ragstone, hard, grey, shelly; *Trigonia costata* (common in the upper portion), *Acanthothyris spinosa*, *Ter. globata*, *Pteria digitata*, *Nerinæa* sp. The top-surface is covered with oysters, and bored in places by *Lithophagi*: seen	2	0

It was from rubble of the *Anabacia*-Limestone equivalent, I think, that the *Prosopon* was obtained at Tor Hill.

Concerning the Winner-Hill section, it may be remarked that there is no clear representative of the Dundry Freestone or of the Upper Coral-Bed. The oyster-covered and bored top-portion of the Upper-*Trigonia* Grit hints at a non-sequence.

VII.—NOTE ON THE OCCURRENCE OF ARENIG ROCKS IN THE WEST OF IRELAND.

By H. B. MUFF, B.A., F.G.S., and R. G. CARRUTHERS.

WHILST examining the tract of Lower Palæozoic rocks and metamorphic schists around Killary Harbour, in Connemara (an examination primarily undertaken to ascertain the relations of the fossiliferous sediments to the schists in that area), an extensive tract of Arenig rocks has been discovered on both sides of the harbour. In 1905 *Didymograpti* of the *extensus* and *superstes* types were found, and during last Summer several specimens of *Phyllograptus* and *Tetragraptus* also, together with many other forms.

Professor Lapworth and Miss Wood (Mrs. Shakespear), who kindly examined some of the best preserved specimens, are of opinion that certain of the graptolites resemble American forms, and may include genera and species new to Britain, though they do not wish to give a definite opinion until more specimens have been obtained. From the evidence already before us it would appear that either a great reversed fault or upturned thrust plane must separate the Arenig rocks on the north from Ludlow beds on the south. The members of both groups dip to the north, the Ludlow rocks passing beneath the Arenig strata. It may be added that an abundance of rock-sections and an apparent absence of acute folding give every hope that the structural relations of the rocks and the distribution of this peculiar fauna may be fully elucidated in the near future.

On the maps of the Geological Survey published in 1874 the lowest fossiliferous Silurian rocks (Doolough Beds) are lettered b^2, and are referred somewhat doubtfully to the Lower Llandeilo in the Memoir on Sheets 83 and 84. During the revision of the district in 1896 black shales with Lower Llandeilo fossils were proved in several localities, and it was suggested that "perhaps even Arenig graptolites" might be present.[1]

[1] Annual Report of Geol. Surv. for 1896, p. 49.

VIII.—Note on the Ballycastle Coalfield, Co. Antrim.

By Grenville A. J. Cole, F.G.S.

THE recent development of mining in the central area of the Ballycastle Coalfield in Co. Antrim has given rise to several articles in the daily Press, and it seems worth while to point out that the occurrence of coal-seams in the interior of the field was long ago proved by borings (see Geological Survey Memoir to Sheets 7 and 8, Ireland, published in 1888); while Mr. Symes's longitudinal section, Sheet 30, published by the Geological Survey of the United Kingdom in 1890, indicated faithfully the geological conditions. The possibility of further development is also mentioned in "Ireland, Industrial and Agricultural," published by the Department of Agriculture for Ireland in 1901.

It was left, however, for the North Antrim Mining Syndicate, in the last two years, to make a systematic trial of the coalfield, and to prove the exact position of the seams of coal. The shaft that has now been sunk, under Mr. Braude's direction, is the result of well-planned preliminary borings. It is hardly necessary to add that, despite the assertions of the Press, the Director of the Geological Survey of Ireland did not furnish any report on the capacity of the field to the Mining Syndicate, though he was freely shown what was going on. Mr. Braude was, moreover, able to point out an extension of the Calciferous Sandstone at one point to the south of the line drawn on the geological map of 1887, and Mr. McHenry has since revised this boundary for the Survey. But no conflict of opinion has been raised between former and present members of the Survey Staff, the geological relations of the strata, coal-seams, and ironstone being already correctly appreciated. Professor Hull's statement in the Report of the Royal Commission on Coal Supplies in 1905, to the effect that the resources of the Ballycastle area "may be considered as practically exhausted," was, it may be added, regarded in Ireland with some astonishment, in view of the records published under his care some eighteen years ago. It is probable from the context, however, that Professor Hull was thinking of the region bordering on the coast, and did not consider the inland area in preparing his report.

REVIEWS.

I.—The Tremadocian Series of Sweden. Note upon the "Bidrag till Kännedomen om Ceratopygeregionen," with special reference to its Development in the District of Fågelsång in Skåne. By J. C. Moberg and C. O. Segerberg, Meddelande från Lunds Geologiska Faltklub. Ser. B, No. 2. Lund, 1906.

THE memoir before us forms the second of an important series of monographs devoted to the study of the detailed palæontology and subdivision of well-recognized stratigraphical series as developed in South Sweden and Scandinavia generally. The present volume deals with the series which Dr. Marr would term Tremadocian, and affords a powerful plea for the retention of that series as the basal member of the Ordovician system.

As stated in the preface, it would seem that the work for the memoir was begun by the author whose name appears second, and submitted as a degree thesis to the Lund University as long ago as 1895. Much of the material then collected was, however, quite new, and as its determination demanded more time than its collector could afford, it was in 1900 allowed to pass by purchase to the collections of the University Museum. Coming then under the direct notice of Professor Moberg the material has later been further worked up by him, to whom the arrangement of the present paper is doubtless due. The memoir is preceded by an author's bibliography, which, except for the strange omission of such names as Sedgwick, Ramsay, Salter, and other founders of our British Tremadoc Series, seems to be quite complete. The memoir is divided into five sections, which we may consider in order.

Part I is an abstract of the papers mentioned in the bibliography, which are quoted as a history of palæontological discovery among the *Ceratopyge*-bearing beds of Scandinavia and the European continent generally, and discusses at some length the various stages in the evolution of the modern view as to their classification and stratigraphical position. The argument is exceedingly clear, and if a little one-sided is only an advocate's way of stating a strong case. A similar treatment of the history of the shales with *Dictyograptus* and the contemporaneous sandstones and conglomerates with *Obolus* follows, and this with a review of the recent palæontological achievements among Tremadoc rocks of Britain and America concludes the first part of the memoir.

Part II is devoted to a consideration of the possibility of a further subdivision within the *Ceratopyge regio* of various parts of Sweden. In the opening section the *Ceratopyge regio* is defined as being the contemporaneous equivalent of the beds 2*e* and 3*a* of Brögger's Kristiania classification. The *Regio* is therefore directly underlain by the well-recognized zone of *Peltura scarabæoides*, and is overlain by the equally characteristic zone 2 of Törnquist's Lower *Didymograptus* shales (zone of *Didymograptus balticus*). Three very distinct facies of sedimentation are recognized, and the corresponding palæontological table of equivalents is set out as follows:—

	TRILOBITIC FACIES.	GRAPTOLITIC FACIES.	BRACHIOPOD-BEARING FACIES.
Upper Division.	Zone of *Apatocephalus serratus*, or Ceratopygekalk.	Zone with *Tetragraptus phyllograptoides* (zone 1 of Törnquist's *Didymograptus* shales).	Not yet studied.
	The *Shumardia* zone, or Ceratopygeskiffer.	Zone of *Clonograptus heres* (Wgd.), MSS., n.sp.	Not separated from lower zone; contains *Obolus Apollinis*.
Lower Division.	Zone of *Symphesurus incipiens*, not recognized in Sweden.		
		Zone of *Bryograptus Kjerulfi*, along with *Clonograptus tenellus* and var.	
	Zone of *Hysterolenus Törnquisti*, *Boeckia Mobergi*, and *Acerocare* sp.	Zone of *Dictyograptus flabelliformis*.	Zone with *O. Apollinis* (*Obolus* conglomerate and sandstone).

This scheme is in all essentials in complete agreement with the conclusions which I shall express in another place, and is particularly satisfactory to British geologists in that by the inclusion of the *Boeckia* and *Acerocare* zone within the *Ceratopyge regio* the lower limits of that *regio* and of the Tremadoc Slates of Britain become once more identical. The weakest link in the scheme seems to be the presumed contemporaneity of the *Apatocephalus*-bearing Ceratopygekalk, with the graptolite shales with *Tetragraptus phyllograptoides*. The only direct evidence put forward for this contemporaneity is that about Hunneberg in Vestergötland Moberg and von Schmalensee found in 1892 a 2–3 inch band of nodular glauconitic limestone containing *Symphysurus* and *Megalaspis* occurring above the *Tetragraptus phyllograptoides* beds, and they consider that this must be regarded as the *Apatocephalus serratus* zone. In my own examination of the same section last Summer, however, I found that both the basal member of the paler grey shales which underlie the graptolite beds and the highest bank of the dark pyritous 'jernberg' contain *Apatocephalus*; and though I am willing to admit that the greater part of the 'jernberg' contains a fauna more like that of the Ceratopygeskiffer of Norway than that of the Ceratopygekalk of either Öland or Skåne. I am not at all prepared to regard that evidence as convincing proof of the replacement of the *Apatocephalus* zone by *Tetragraptus* shales. The indirect evidence that graptolite beds are generally absent where, as in Öland and Östragötland, the Ceratopygekalk is best developed is certainly striking, but even there *T. phyllograptoides* beds might just as well be represented by Planilimbatenkalk as by the Ceratopygekalk with *Apatocephalus*. In eastern Skåne too the zone of *T. phyllograptoides* is quite well developed, and, as shown by Linnarsson, Holst, and Westergård, is underlain by pale glauconitic and brachiopod-bearing shales and limestone nodules which may well be the *Apatocephalus* beds themselves. In the Kristiania district the *T. phyllograptoides* fauna does not seem to have been recorded, but, unless I am much mistaken, the graptolitic beds which come nearest to the glauconitic Ceratopygekalk at Gjeitungholmen in Kristiania Fjord may with great probability be referred to some part of that zone, and are interbedded with limestone bands very like the upper nodular limestone of Hunneberg discussed above. If, however, Professor Moberg and Dr. Segerberg will admit, as they seem to suggest on p. 44, that the *Ceratopyge regio* shall include some part of the Öland Planilimbatenkalk, the inclusion of the *Tetragraptus phyllograptoides* beds will, I think, be justified, and the upper limit of the Tremadocian as so defined, though somewhat arbitrary in its conception, will at least have the great advantage that it can be recognized and traced over wide areas and through all kinds of sediments. The effect of such a change of nomenclature upon British literature would be hardly noticeable, for except among the Durness Limestone of North Scotland and in the Lake Country the beds affected are represented only by an unconformity. The inclusion of Miss Elles' Lower *Tetragraptus* beds of the Skiddaw Slates with the *Bryograptus* shales of the same series within the Tremadocian would not, I think, be very inconvenient, and the boundary between them has never been mapped, while the recognition that the Arenig rocks of Arenig include representatives of all the major divisions of the Arenig Series as known elsewhere cannot be regarded as other than a welcome simplification of our nomenclature.

Part III deals with the discovery and detailed description of the Fågelsång section, which now, buried beneath a scree of most unnecessary rubbish, has yielded much valuable palæontological material and intrinsic evidence in favour of the succession already discussed in part II.

Part IV describes the geographical distribution of localities at which the various members of the tabulated succession have been observed.

Part V is the newest and probably the most valuable portion of the whole work; it is a palæontological appendix or monograph of all genera and species which are known to occur within the *Ceratopyge regio* (excluding the *Tetragraptus phyllograptoides* zone) of Scandinavia. The forms discussed are referred to 97 species belonging to 52 genera, and of these 3 genera and 33 species, besides 3 varieties, are described as new. All Swedish forms (and only some 9 of the Norwegian species have not been recognized in Sweden) are represented by one or more beautifully executed figures, some of which are only reproductions of original type figures, but these are in most cases accompanied by one or more carefully drawn new figures of the best obtainable specimen of the species. To each species also is appended a full account of its older figures and synonymy and a list of the more important localities at which it has been recognized. A tabulation and analysis of the occurrence of the individual species among the proposed subdivisions gives the following result:—

(*d*) *Apatocephalus* zone	62 species.
(*c*) *Shumardia* zone	29 species.
(*b*) *Bryograptus* zone	16 species.
(*a*) *Dictyograptus* zone	13 species.

Of these only two species are common to (*a*) and (*b*), 4 to (*b*) and (*c*), 16 to (*c*) and (*d*), and only the single species *Obolus* (*Bröggeria*) *Salteri* is known to range through all divisions. In the final zoological analysis attention is drawn to the preponderance of the trilobites (45 species) over Brachiopods (22) and Graptolites (8), but had the *Tetragraptus phyllograptoides* beds and their equivalent been included in the estimate, the result might have been very different, and from my own visit to the *Ceratopyge regio* last Summer I have certainly rather retained the impression that that *regio* is a *regio* of graptolites which includes certain trilobitic and brachiopod-bearing bands.

In conclusion, on behalf of all British students of the Cambro-Ordovician rocks, I will venture to offer my thanks and congratulations to Professor Moberg and Dr. Segerberg on the completion of this useful and monumental monograph of the palæontological aspect of the Scandinavian Tremadocian, and will remark that while its publication does not actually bring about the elucidation of our British Tremadoc rocks it does at least suggest the mode of attack, and in the meantime places in our hands a means of identification of certain of our material such as we might have prayed for. The volume is beautifully printed, and the collotype reproductions of the seven plates with their two hundred odd figures leaves little to be desired. Why should not some enterprising British Field-clubs emulate this excellent example of a small university field club and give us similar detailed monographs of interesting British deposits? We are indeed behind the times. WILLIAM G. FEARNSIDES.

II.—GEOLOGICAL SURVEY OF CANADA. By ROBERT BELL, I.S.O., M D., F.R.S., etc., Acting Director. Annual Report (New Series), Volume XIV, Reports A, B, F, H, J, M, O, S, 1901. 8vo; with maps. (Ottawa: S. E. Dawson, 1905.)

THE Summary Report (A) of this volume (271 pp.) is for the year 1901; it consists, as usual, of a synopsis of the work done by the field staff, as well as the Museum and office staff. A brief account is given, under the head of "Officers' Reports," of explorations and surveys carried on in all parts of the Dominion, from Yukon in the west to Cape Breton Island in the east. The bare enumeration of all the districts visited by the staff would occupy a considerable space, as there are upwards of thirty. These reports will be reviewed when they are published separately and *in extenso*. One exception may, however, be made. Mr. Lawrence M. Lambe gives descriptive notes on some interesting turtle remains collected during the Summer of 1901 (?) in the Cretaceous rocks of Red Deer River, Alberta. These are referred by Mr. Lambe to *Trionyx foveatus*, Leidy, and *T. vagans*, Cope. The fossils consist of almost complete carapaces of these species, and they supplement in an interesting manner the material obtained in former years.

Report B (R. G. McConnell on the Klondike Gold Fields); Report J (R. W. Ells on the geology of a portion of Eastern Ontario); and Report O (F. D. Adams and Osmond E. Leroy on the artesian and other deep wells on the Island of Montreal), have already been reviewed in the GEOLOGICAL MAGAZINE in 1906.

Report F is a short report by Mr. D. B. Dowling on an exploration of Ekwan River, Sutton Mill Lakes, and part of the west coast of James Bay, with two appendices. The formations observed in the district were: (1) the Cambrian rocks of Sutton Mill Lakes; (2) the Silurian limestone bordering the west shore of James Bay and the south shore of Hudson Bay; and (3) the clays, of Post-Tertiary age, which form the general covering over nearly all the country left by the ancient glacier and the retreating ocean. The appendices consist of a preliminary list of fossils from the Silurian (Upper Silurian) of the Ekwan River and Sutton Mill Lakes, Keewatin, collected by the author in 1901, and afterwards described in full in "Palæozoic Fossils," vol. iii, part 4, 1906, by Dr. J. F. Whiteaves, and a list of 41 species of plants, by Professor John Macoun. The report is illustrated from photographs and original drawings.

Report H is on the origin, geological relations, and composition of the nickel and copper deposits of the Sudbury Mining District, Ontario, by Dr. Alfred Ernest Barlow. Much importance must be attached to this memoir, both from its scientific interest and from the great value of the deposits of nickel so fully described in it. As the report covers

236 pages it will only be possible to bestow a mere glance upon it. The report begins with a history of the development of mining in the Sudbury district, and then goes on to describe its general physical features and geology. The rocks of the district are, in ascending order, as follows:—

1. Lower Huronian. No rocks of this age are at present known in the nickel-bearing area, but this period is represented in part by the banded siliceous magnetites and associated rocks of Hutton and Wissner.

2. Upper Huronian. (*a*) Diorites, hornblende-porphyrites, and green schists; (*b*) conglomerates, greywackes, and quartzites; (*c*) norite and diorite (Worthington mine belt and areas south-east of Evans mine and east of Sudbury).

3. Laurentian. Granite and diorite-gneiss near Wanapitei station.

4. Upper Huronian? Tuffs, felspathic sandstones, and slates classified provisionally on previous geological maps as of Cambrian age.

5. Post-Huronian. (*a*) Granites; (*b*) nickel-bearing eruptive of the main belt (quartz-hypersthene-gabbro or norite, diorite, with their peculiar differentiation product, micropegmatite); (*c*) dykes of olivine-diabase.

6. Pleistocene. Clays and sands.

The granites referred to in the list (5, *a*) are pronounced to be undoubtedly younger in relation to the older diorites, porphyries, and green schists, and a rock which may be called a breccia, formed by an exceedingly intricate intrusion of dykes and masses of granitic material through these basic rocks, covers considerable areas throughout the district.

The nickel-bearing eruptive (5, *b*) is said to be decidedly later than, and intrusive through, the green schists and associated diorites (2, *a*).

The olivine-diabase dykes (5, *c*) cut through, and are therefore later than, all the rocks with which they have been seen to be in contact.

A description is given of the minerals associated with the nickel and copper of the Sudbury region, followed by an account of the methods of mining, metallurgy, and smelting. The nickel deposits of the United States, Scandinavia, and New Caledonia are also described at some length.

The report concludes with a series of statistical tables of the production of nickel in Canada, which is the largest producer in the world; other countries being added for comparison.

This important memoir is well illustrated with plates, maps, and plans.

Mr. Henry S. Poole reports briefly on the Pictou Coalfield of Nova Scotia. This famous coalfield has long been known to geologists through the writings of Gesner, Dawson, Lyell, and Logan. The present report has been written to accompany a revised map of this coalfield and its neighbourhood lately published. The district contains in a small area a wide field for investigation, supplying representative series of several geological epochs and many highly instructive exposures of varied structure.

The geological systems represented are as follows, in ascending order:—

1. Cambro-Silurian.
2. Silurian.
3. Devonian.
4. Carboniferous Conglomerate } Lower
5. Carboniferous Limestone } Carboniferous.
6. Millstone Grit.
7. Coal-measures.
8. Permian.
9. Igneous intrusions in deposits of several ages.
10. Pleistocene.

The detailed Annual Report of the Section on the Mineral Industries of Canada for 1901 by E. D. Ingall and assistants comes next. The report is accompanied by a table of the mineral production of Canada for the calendar years 1886 to 1901.

A very full index and a large number of maps are supplied with this report, which does much credit to the ability and industry of those who have contributed to it. A. H. F.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 19th, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec. R. S., President, in the Chair.

The following communications were read:—

1. "The Post-Cretaceous Stratigraphy of Southern Nigeria." By John Parkinson, B.A., F.G.S.

In this paper, which is a first attempt to outline the sequence of the later deposits of Southern Nigeria (now including the Colony of Lagos), a series of beds are described from four localities—three from the western side of the Niger, and one around Calabar near the Kameruns frontier. The alluvium of the river-beds and the lower terraces are referred to, and the succeeding sediments grouped under three heads.

The youngest of these, termed the Benin Sands, are of wide distribution, and are found extensively developed in all four areas. Their almost universal appearance near the coast, and the height, occasionally 300 feet, to which their denuded tops are now raised above sea-level, indicate an important submergence and subsequent elevation in comparatively late times, while from the latter much of the present physiography appears to date. The Benin Sands have been seen in contact with both the older groups of sediments, but unfortunately the work has not proceeded far enough yet to show conclusively the relationships of the latter.

The older of the two, the Lignite Series, occurs typically near Asaba on the Niger, although indications of a similar deposit have been met with near Moroko, south of Abeokuta; the younger, the Ijebu Series, has so far been found only in that district of the Lagos Province. These beds are extensively impregnated with bitumen. The suggested difference of age depends on the lesser dip and degree of consolidation of the Ijebu Series. In them a few lamellibranchs have been found, of no value as regards the determination of the horizon, and some plant-remains; in the Lignite Series only undeterminable plant-remains. The Benin Sands are apparently unfossiliferous. The information regarding the Ijebu Beds has been derived almost entirely from boreholes.

2. "The Geology of the Oban Hills (Southern Nigeria)." By John Parkinson, B.A., F.G.S.

The country described in this paper comprises some 1,800 square miles of the Eastern Province of Southern Nigeria, adjacent to the Kameruns frontier. The rocks are crystalline, principally gneisses and schists, with later granites, pegmatites, and basaltic dykes, surrounded on the north, west, and south by Cretaceous sediments. For purposes of description the series is divided under nine headings, according to locality and petrographical character; and it is concluded that, neglecting the basaltic dykes, two broad groups may be distinguished—the one characterized by the presence, the other by the absence, of foliation. In the former the foliation tends to be lost, giving a passage between types which petrographically are acid orthogneisses and granites.

Observation of the banded gneisses, which are typical of several districts, leads to the conclusion that the acid magma is intrusive into mica and hornblende schists, and that the banded gneisses are composite rocks produced by injection. The orthogneisses themselves exhibit many variations; and study in the field shows that the series consists of several members, produced by the differentiation probably of one magma, which have reached their present positions at different times: that is, they differ slightly in age. At Uwet was found a group of phyllites and grits altered into garnet, andalusite, and staurolite-schists, and hornfels, with the development of much biotite, by an intrusive gneiss; and it is considered as probable, though not capable at the time of absolute proof, that the sillimanite-gneisses of the Ekankpa ford, a few miles away, are the result of an extension of the same belt of contact-metamorphism, a suggestion which possibly might truly include the schists of the entire district.

Typical specimens of the granites, pegmatites, and dykes are described, and sketch-maps given.

3. "The Crystalline Rocks of the Kukuruku Hills (Central Province of Southern Nigeria)." By John Parkinson, B.A., F.G.S.

In this paper a short account is given of the crystalline rocks found in the Central Province of Southern Nigeria, between the Station of Ifon (north of Benin City) and the Northern Nigerian frontier. The rocks fall under two heads—(*a*) a group of gneisses and (*b*) a group of schists.

The former is considered as intrusive in the latter, and consists of varieties of biotite gneisses, often well banded, but this group is not infrequently represented by several rocks readily separable by mineralogical peculiarities and by intrusion.

By loss of foliation the gneisses tend to pass into granites, and the series is accompanied by pegmatites.

The second group is distinguished by the wide distribution of quartz-schists, with which occur quartz-mica-schists, mica-schists (locally containing sillimanite), and hæmatite-schists. A partial analysis of a specimen of the last-named showed 67·77 per cent. of iron-peroxide.

The district is compared with the Oban Hills of the Eastern Province.

II.—January 9th, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communications were read:—

1. "On the Cretaceous Formation of Bahia (Brazil) and on the Vertebrate Fossils contained therein." By Joseph Mawson, F.G.S., and Dr. Arthur Smith Woodward, F.R.S., F.L.S., F.G.S.

This paper relates to a series of estuarine and fresh-water deposits originally described to the Geological Society by the late Samuel Allport, in 1859. The results of thirty years' collecting of fossils are summarized, and the distribution of the formation, so far as determined, is marked on a map. The strata are disturbed by numerous dislocations and discordant dips, and no regular succession of zones or horizons can be discovered. All the more important vertebrate fossils collected are now in the British Museum (Natural History). From these a few remains of new species are selected for special description. A mandibular symphysis of a very large crocodile, with a long garial-like snout, belongs to one of the Goniopholidæ. Some Dinosaurian vertebræ seem to belong to the Iguanodont group. A large fish-skull represents a new genus allied to *Macropoma*, and indicates a species five or six times as large as any Cœlacanth previously discovered. The discussion of a complete list of the fossil Vertebrata proves that the formation is of Cretaceous age, and suggests that it may be Lower Cretaceous, as supposed by Hartt.

[Mr. R. B. Newton stated that Mr. Mawson's collections contained some interesting molluscan remains, among which were a number of Anodont—or Unioniform—shells suggestive of *Unio porrectus* and *U. antiquus* of British Wealden areas, associated with *Vivipara*- and *Melania*-like Gasteropods, all of which had been studied by Professor Hartt and later by Dr. C. A. White, both being of opinion that they belonged to the Lower Cretaceous. The vertebrate evidence now brought forward by Dr. A. S. Woodward, especially the newly recorded occurrence of *Goniopholis*, together with the *Lepidotus*-scales originally determined by Egerton, was strong confirmation as to the Lower Cretaceous age of these deposits.]

2. "On a New Dinosaurian Reptile from the Trias of Lossiemouth, Elgin." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., F.G.S.

Mr. William Taylor, of Elgin, has recently discovered two skeletons of a small new reptile in the Triassic sandstone of

Lossiemouth. Two imperfect skeletons of the same species are also shown on a slab of the same sandstone in the British Museum (Natural History). The head and trunk measure only 4 inches in length, but there is a very long and slender tail. The head is relatively large, and resembles that of *Ornithosuchus* in many respects; but the fossils do not exhibit any teeth. There are about twenty-one presacral vertebræ, of which nine are cervical. There are distinct traces of a plastron of delicate abdominal ribs. The limb-bones exhibit a large internal cavity. The fore-limbs are very small, with a humerus as long as the radius and ulna. The hind-limbs are relatively large, and the ilium is extended antero-posteriorly for the length of four vertebræ. The femur is almost as long as the tibia and fibula; while the metatarsus is especially remarkable, being half as long as the tibia, and consisting of four metatarsals of nearly equal length firmly fused together. The toes are long and slender, with sharply pointed claws. The author concludes that this must have been a running or leaping reptile, and that it represents a new genus of Dinosauria related to the American Triassic *Hallopus*.

MINERALOGICAL SOCIETY.

November 13, 1906.—Prof. H. A. Miers, F.R.S., President, in the Chair.

Growth of crystals of soluble salts on each other, by Mr. T. V. Barker. This paper is a continuation of the author's previous work on the growth of salts on isostructural minerals to those of soluble isomorphous salts on each other. The group now investigated is that of the chlorides, bromides, iodides, and cyanides of Na, K, Rb, Cs, and Am, which crystallise in the cubic system. The view previously entertained that parallel growths are conditioned by a similarity of molecular volume is again found to hold good; some apparent exceptions are explained by the presence of isodimorphism. One pair of salts, however, $NaCl–KCl$ yield parallel growths, although the molecular volumes are greatly different; this is perhaps to be accounted for by the fact that the molecular volumes are almost exactly in the ratio 1 : 2.—Notes on some Bolivian minerals, by Mr. L. J. Spencer. Descriptions are given of crystallised Jamesonite, Semseyite from Oruro, new crystal-forms on Andorite, Chalcostibite from Oruro, Augelite from Oruro, Vivianite from Tatasi and Tasna, Tetrahedrite from Huanchaca, regular grouping of Stannite and Tetrahedrite, Valentinite, Cassiterite, Tourmaline, and Tourmaline-hornfels, Fluor, Apatite, cupriferous Miargyrite from Tatasi, crystallised Miargyrite from Aullagas, Jarosite from Chocaya, Chalybite from Chorolque and Tatasi, Enargite from Chorolque.—Note on Ilmenite from Brazil, by Mr. G. F. Herbert Smith. The crystals have three habits, *cam*, *camr*X, *cn*X*rs*, differing slightly from those described from the same locality by Hussak. The hemihedrism is shown by striations on the prism faces; some magnesium is present.—Description of the Lengenbach Quarry and of the minerals found there in 1906, by Mr. R. H. Solly. The now well-known quarry was opened about the year 1850, and various new minerals were described by Des Cloizeaux and others. From 1860–70 a level was driven in a direction at right angles to the stream, and in it were found the specimens described by Von Rath. In the decade 1890–1900 a little work was done each Summer, resulting in the specimens studied by Baumhauer. Since 1900 Francis Jentsch and his partners have worked the quarry regularly each Summer. In 1902 they came across the old tunnel constructed in 1731, the existence of which had been quite forgotten. Up to 1898 eighteen mineral species had been found, of which four are peculiar to the quarry; since that date twenty-five additional species, of which no fewer than twenty are new to science, have come to light. Nine of the new species have been named, two are pseudomorphs, and nine, owing to paucity of material, have not yet been described. The minerals found this year include Trechmannite (fine crystals), Baumhauerite (curiously striated and distorted crystals), Seligmannite (a large crystal 20 mm. in length), Jordanite (a twin about 301), Dufrenoysite (a twin about 001), pseudomorphs of Dolomite and Baumhauerite after Scapolite (?).—Note on the Thirty-two Classes of Symmetry, by Mr. H. Hilton. — Specimens of Turnerite from Cornwall were exhibited by Mr. Russell, and crystals of Sartorite by Dr. Trechmann.

CORRESPONDENCE.

THE SOMABULA DIAMOND FIELD.

SIR,—I notice in your December issue[1] a comment by Dr. Flett on my paper on the Somabula Diamond Field, and I take this opportunity of expressing my regret that it was published just before a further visit to the field under the more favourable conditions now prevailing. It is unquestionable, as Dr. Flett implies, that most of the mineral locally regarded as enstatite is really staurolite. It did not occur to me to doubt the original determination of this mineral as a rhombic pyroxene, until I recently secured some fragments with faces showing the characteristic angles of staurolite. Andalusite may also be added to the list of what I have termed "unequivocal contact minerals." There can be no doubt, in fact, that the characteristic minerals of the alluvial deposit come chiefly from the margins of the granite mass which it overlies.

But this does not in the least alter the position as regards the original source of the diamonds. It is significant, for instance, that though diamond is almost exactly of the same specific gravity as chrysoberyl, topaz, and staurolite, the quantity of these latter has no relation whatever to the abundance or even to the presence of the diamond. The only mineral which shows indications of such a relationship is garnet, a possible 'pipe' mineral, by the way. The sapphires, rubies, and chrysoberyls are also exceedingly water-worn, while the diamonds are in many cases perfectly unabraded, though those found in the present-day stream which cuts into the old alluvial are usually considerably worn, showing they are susceptible to wearing action.

Perhaps a local experience of over five years and the fact of having made most careful field examinations of the vicinity may be permitted to weigh something in the scale against "an inspection of the minerals." I fancy, too, that my acquaintance with the literature of the diamond is more extensive than Dr. Flett's, in spite of my having been for years out of reach of a scientific library. I have also studied specimens from most of the important diamond localities that I have been unable to visit. And I can only record my conviction, after a review of all the facts, firstly, that the Somabula diamonds, as also those of Brazil, India, and New South Wales, are derived from quite a different source from that of the sapphire, topaz, chrysoberyl, staurolite, kyanite, etc., with which they are associated, as has indeed been actually proved in the case of New South Wales; and secondly, that there is nothing to contradict the idea that the ultrabasic rocks ('blue-ground' and its allies) are invariably the source of the diamond.

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[1] See GEOL. MAG., December, 1906, pp. 569–570.

The question is no mere academic one. I should be only too delighted to gain an opportunity of describing a new matrix for the diamond. This, however, is the position. I am every day asked for advice by prospectors, men whose livelihood depends on their success in finding mineral deposits of possible economic value. When consulted about diamonds, what is one to tell such men as these? In face of the fact that every South African mine (and there must be at least thirty now working) is in 'blue-ground,' is one to advise them to look for diamonds in staurolite or kyanite schists? Some, through ignorance, have actually done work on such rocks—needless, to say, without finding any diamonds. I even know of a locality where staurolite, kyanite, tourmaline, garnet, and rutile can be got from a single specimen. Could one in good faith urge the spending of money on it in the hope of its developing into a diamond-mine? I certainly do not think so myself, whatever other people's views may be. F. P. Mennell.

Rhodesia Museum, Bulawayo.
December 28*th*, 1906.

MARINE RIPPLE-MARK.[1]

Sir,—. . . . Will you permit me to point out that in Mrs. Ayrton's researches on Sand-ripples, so far as they concern geologists and marine ripple-mark, there are four *experimental* fallacies. Mrs. Ayrton describes her apparatus as follows: "In this trough, six feet long . . . . the water, which is about a foot deep, is now made to swing periodically backwards and forwards by means of an electro-motor" (Abstract of lecture to Section G at Cambridge in 1904).

In the real thing we find a series of periodically oscillating waves moving in one direction over a fixed bottom, and expending themselves on a sandy shore. In Mrs. Ayrton's experiment we have an oscillating bottom, perfect reflection from vertical ends, waves moving in opposite directions, and, as one result, stationary waves in the experimental tank. None of these four conditions obtain at sea, and Mrs. Ayrton's results and conclusions, interesting though they are to physicists, have practically no bearing on the phenomena of the sea-shore and the sea-bottom. A. R. Hunt.

Southwood, Torquay.

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[1] [Unavoidably delayed in publication by want of space.—Ed. Geol. Mag.]

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ORIGINAL ARTICLES.

I.—Note on some Vertebrate Remains collected in the Fayûm, Egypt, in 1906.

By C. W. Andrews, D.Sc., F.R.S., F.G.S., British Museum (Natural History).

THE collecting expedition to the Fayûm in the Spring of 1906 did not result in the discovery of any striking new forms, but nevertheless a large number of specimens was obtained, some of which add considerably to our knowledge of species already imperfectly described. Of these specimens the most important are: (1) An associated skull and mandible of *Palæomastodon wintoni* with the upper and lower dentition, including the tusks, in perfect preservation; an atlas, humerus, radius, part of an ulna, and some vertebræ of the same individual were also found, and confirm the determinations that had previously been made from isolated examples. (2) A beautifully preserved mandible of a very young *Palæomastodon*, probably the same species. In this specimen the two posterior milk-teeth are in position, while the anterior one is represented by its empty alveolus. Beneath the two milk molars are the germs of pm. 3 and pm. 4, almost ready to replace them vertically in the ordinary way. The first molar is in wear, and the crown of the second is fully developed, but had not been cut. One of the most interesting points, however, is that the outer edges of the incisors are serrated, so that this specimen finally proves that the genus *Phiomia* was founded on the anterior portion of a very young mandible of one of the smaller species of *Palæomastodon*, as indeed has already been suggested by Schlosser.[1] The above-mentioned specimens will be described in detail elsewhere. Of the remainder, perhaps the most interesting is a portion of the jaw of the remarkable animal *Geniohyus mirus*, the type-specimen[2] of which is the anterior region of a mandible in which all the cheek-teeth except the talon of m. 3 are well preserved. The most peculiar feature of this specimen was described as being the presence of a downwardly and backwardly directed hook-like process arising from the ventral surface of the ramus immediately behind the symphysis. Another peculiarity noted was the extreme narrowness of the ramus beneath the cheek-teeth. It is, however, seen from the present specimen (Fig. 1) that the condition of things was even more remarkable than was supposed, and that the hook-like process was merely the thickened antero-inferior border (*l.b.*) of a large bullate expansion (*foss.*) of very thin (1–2 mm.) bone projecting outwards and forming a large prominence on the postero-inferior portion of the mandibular ramus. Superiorly this is continuous with the outer face of the narrow thickened alveolar part of the ramus; it is convex externally and concave internally. Posteriorly it is strengthened on the inner side by a rounded vertical buttress (*p.b.*) of bone situated about the level of the talon of m. 3. What the function of this inflated expansion of the lower portion of the mandible may have been it is difficult to conjecture. It may possibly have lodged a very large salivary gland or some kind of buccal sac, perhaps connected with the vocal organs. Another peculiarity of this specimen is that behind the last molar there is a foramen that perforates the base of the ascending process and opens on the inner side of the jaw; so far as I am aware, this only occurs in the Hyracoidea, and its presence here suggests the possibility that *Geniohyus* may have some relationship with that group, though from the cheek-teeth alone it would certainly be regarded as not remotely related to the Suidæ. The teeth are well preserved, and agree precisely in structure with those of the type-specimen, though slightly more worn. The talon of m. 3 is complete. It is large and composed of a large main cusp, on the antero-internal side of which is a small accessory tubercle. The valley between the talon and the body of the tooth is partly filled by an accessory tubercle of the postero-external main V.

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[1] Neues Jahrb. f. Min., etc., vol. i (1905), pt. 1 (Referate), p. 157.

[2] Geol. Mag., Dec. V, Vol. I (1904), pp. 160–161, Pl. VI, Fig. 4.

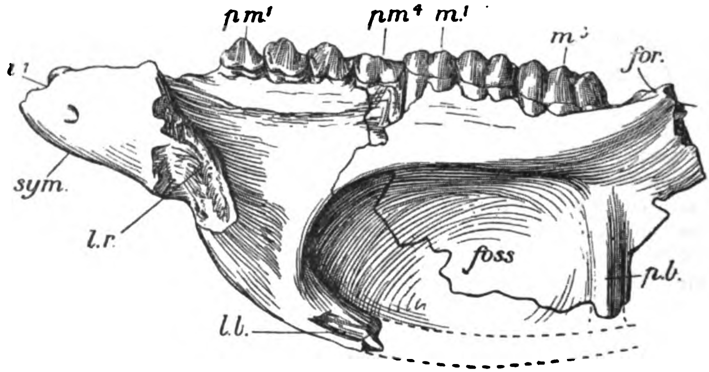

Fig. 1.—*Geniohyus mirus*. Right ramus of mandible from the inner side. The portion of the figure behind the black line is drawn from the new specimen; the anterior portion and the ventral border is from the type-specimen. *for.* line showing the position of the foramen perforating the base of the ascending ramus; *foss.* the inner concave surface of the bullate expansion; *i.* 1, base of first incisor; *l.b.* ventral thickened border of mandible; *l.r.* broken anterior end of the right ramus of the mandible; *m.* 1–3, molars; *p.b.* posterior buttress; *pm.* 1–4, premolars; *sym.* symphysial portion of mandible. ½ nat. size.

The dimensions (in centimetres) of the teeth in the new specimen are:

	Length.	Width.
pm. 4	1·2	1·0
m. 1	1·4	1·1
m. 2	1·7	1·3
m. 3	2·4	1·5

A fragment of the left ramus of the mandible with one molar tooth (first or second) seems to belong to the large species of *Geniohyus*, *G. major*, and shows that in that also the peculiar structure of the mandible existed, though whether to the same degree as in *G. mirus* cannot be determined without more material. The dimensions of the molar are: 2·6 cm. long, 1·6 cm. wide. Unfortunately the structure of the skull in this extraordinary animal remains at present quite unknown.

Other specimens of interest are portions of the mandible of *Saghatherium magnum*, one of which consists of the almost complete left ramus (Fig. 2) with the canine premolars and molars well preserved.

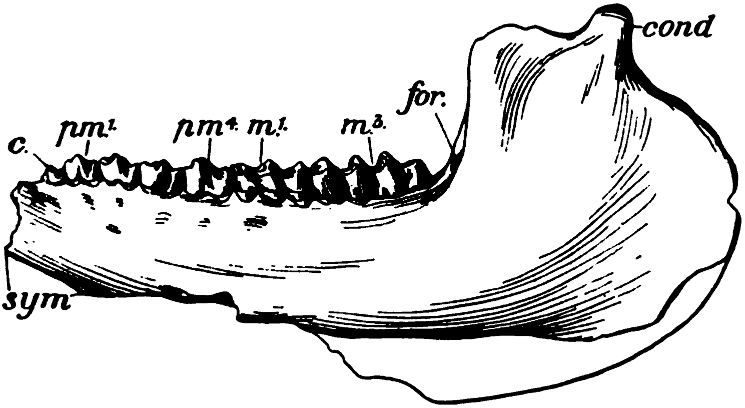

Fig. 2.—*Saghatherium magnum*. Left ramus of mandible, outer side. *c.* canine; *cond.* condyle; *for.* foramen in base of ascending ramus; *m.* 1–3, molars; *pm.* 1–4, premolars; *sym.* symphysis. The lower outline of the angular region is taken from an undistorted specimen. ⅔ nat. size.

The jaw has been somewhat crushed, in such a way as to diminish its depth beneath the hinder molars and in the region of the angle, the full depth being shown in the second specimen, the outline of which is shown in the figure. On the whole, this mandible agrees very closely with that of the recent Hyracoids. Thus, the perforation (*for.*) of the base of the ascending process just behind the last molar occurs as in *Hyrax*, the angular region is greatly expanded, the posterior portion of the jaw being very deep. The coronoid on the fossil may have been a little less prominent than in the recent forms. The teeth are arranged in a rather strongly curved closed series. The canine which is slightly broken in front is a premolariform tooth, the crown of which consists of a compressed main cusp, with small posterior and probably anterior accessory cusps: this tooth seems to be borne by a single root, somewhat compressed from side to side. The premolars and molars agree with those already described in the Catalogue of the Fayûm Vertebrates (p. 87).

The total length of the mandible here figured is 13·8 cm., its depth beneath the condyle about 6·5 cm. The lengths of the teeth in millimetres are: canine, 4 app.; pm. 1, 7; pm. 2, 8; pm. 3, 8; pm. 4, 9; m. 1, 10; m. 2, 13; m. 3, 18. The total length of the tooth series (c. to m. 3) is 7·5 cm.; the length of the molar series is 4 cm.

In the other specimen the depth of the ramus beneath m. 3 is 4·3 cm., and the distance from the hinder end of m. 3 to the posterior border of the mandible is about 5·5 cm.

Several more or less imperfect curved front upper incisors of Hyracoids were collected. They were of varying size and are triangular in section, the two anterior faces only being covered with enamel.

The remains of Carnivora are very rare, and few were obtained, the most important being a fragment of the left maxilla, with two teeth (pm. 4 and m. 1). The molar is almost exactly intermediate in form between the corresponding teeth in *Pterodon* and *Hyænodon*, having a less prominent inner tubercle and longer posterior blade than in the former, but in these characters more resembling the latter. It seems, therefore, that this maxilla belonged to *Apterodon macrognathus*, a species founded on a mandible, the dentition of which is likewise in some respects intermediate between that found in the genera above referred to; it also agrees in size with the specimen now under consideration.

An enormous canine, probably that of *Pterodon africanus*, some cervical vertebræ, and a tibia were also obtained.

One rather notable find was the ulna of a large wading bird, apparently nearly allied to *Ardea*. Compared with the same bone of *Ardea goliath*, this ulna is somewhat smaller and notably stouter in proportion to its length, but in the form of its extremities and of the various muscle impressions it is closely similar. Bird bones are extremely rare in these beds, at least in sufficiently good condition to collect.

No notable reptilian remains were found.

It will be seen that very much more remains to be done in the Fayûm, many of the animals described being only very incompletely known, from mere fragments; in several important instances, e.g. *Geniohyus*, the skull remains quite unknown.

II.—NOTES ON THE ROCKS OF THE "BEAGLE" COLLECTION.

I.

By ALFRED HARKER, M.A., F.R.S.

THE voyage of the "Beagle" in 1831–6 was not only the starting-point of Charles Darwin's scientific career, but also, and more particularly, it laid the foundation for the whole of his geological work, as embodied in the well-known series of volumes.[1] The collections which he gathered during that prolonged voyage of exploration have therefore no small interest of a historical and sentimental kind. It is believed that they possess also a certain intrinsic value; inasmuch as an examination of these original specimens, with the advantages conferred by modern petrographical methods, may sometimes help towards a better understanding of the recorded observations. Owing to his choice of plain language in preference to the now antiquated terminology of his time, Darwin is seldom obscure to a modern reader; but his characterization of the igneous rocks which he observed is necessarily crude and vague. Not a few passages may be considerably elucidated by merely indicating the nature of the rocks which are designated by such old-fashioned comprehensive names as 'porphyry,' 'greenstone,' and 'basalt.' In general, no more than this will be attempted, at least for those islands and districts which have been studied by other geologists with the aid of modern appliances.

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[1] "Journal and Remarks," 1839; 2nd edition, entitled "Journal of Researches . . . during the Voyage of H.M.S. 'Beagle' . . . ," 1845. "The Structure and Distribution of Coral Reefs," 1842. "Geological Observations on the Volcanic Islands . . . ," 1844. "Geological Observations on South America . . . ," 1846.

The greater part of the "Beagle" collection is now housed in the Sedgwick Museum at Cambridge. It includes some 2,000 rock-specimens, a certain number being lost or missing, and most of the fossils having passed long ago into other hands. Procured often under difficult conditions, carried in many cases long distances overland, and stowed in a confined space on shipboard, the specimens are for the most part not of the size and shape favoured by museum collectors; but they are sufficient to illustrate the rock-masses which they represent, and to provide thin slices for microscopical examination. The original annotated catalogue, occupying four closely written note-books, is a monument of patient labour. Under each number is a condensed description of the rock, as seen by the eye and the lens, besides the necessary records of locality and occurrence. On the opposite page are additional notes, also made during the voyage, giving the results of examination with the blow-pipe, goniometer, magnet, and acid-bottle. Less commonly there are entries made at some later time, sometimes noting an opinion of Henslow or Miller, to whom particular questions had been referred. A copy of this manuscript list is placed with the collection, and it will be referred to as the "Catalogue."

SANTIAGO, CAPE VERD ISLES.

Although we shall in general omit petrographical details, some exception may be made in the case of rocks which have an interest of their own, and have not become generally known from published descriptions. Such are the lavas of the Cape Verd Isles, which present a considerable range of variety and include some remarkable types. The valuable work of Doelter[1] does not pretend to completeness; and these islands have been so seldom visited by geologists that specimens collected seventy years ago may still furnish interesting material for study.

Both on the outward and on the homeward voyage the "Beagle" touched at Porto Praya, on the south coast of Santiago,[1] the largest of the Cape Verd group. Darwin utilised his time in exploring the geology of the port and the neighbouring parts of the island, and collected about 150 specimens. We shall refer to the more interesting of these in the order in which they are mentioned in the first chapter of "Volcanic Islands." Of some of them thin slices have been made, and the number of the slides, in the Sedgwick Museum cabinet, will be given in brackets.

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[1] C. Doelter: "Die Vulcane der Capverden und ihre Producte," Graz, 1882. A few rocks collected by Doelter have been described by Fr. Eigel: Tscherm. Min. Petr. Mitth. (2), vol. xi (1889), pp. 91–104. There are also some earlier notes by A. Stelzner: Berg. u. Hütt. Zeit., vol. xxiv, p. 47.

The lowest rocks on the coast near Porto Praya and on Quail Island, underlying the white Tertiary limestone, are highly basic, non-felspathic lavas. The fresher specimens show a very dark and compact ground-mass, with crystals of yellow olivine and black augite, which are usually very abundant. Three examples which have been sliced illustrate three different types, and probably represent fairly the whole group. The first [4704] is a *limburgite.* Olivine is the dominant mineral, in perfectly fresh well-shaped crystals. Augite is also abundant, in good crystals with some tendency to stellate grouping. It is very pale in the slice, and often shows fine lamellar twinning. There are also a few little octahedra of magnetite, sometimes enclosed in the olivine. These minerals constitute the greater part of the rock, but there is in addition an abundant glassy base of deep brown colour, enclosing very numerous little rectangular gratings of magnetite.

The second type [4705] shows the same minerals, except that the olivine is largely replaced by serpentine and carbonates. The augite is strongly zoned. The ground-mass consists of a second generation of augite and magnetite, with slender needles of apatite and a clear isotropic base, which is quite colourless. This is evidently an example of the second variety of limburgite distinguished by Doelter (op. cit., pp. 134–137) as having a colourless instead of a brown glass. The true nature of the colourless base is, however, doubtful, and we shall recur to the subject below.

The third type [4706] differs from the foregoing in that olivine is scarcely represented. The phenocrysts are of a pale yellowish-brown augite, zoned and often twinned, with magnetite. The ground-mass consists, as in the last specimen, of abundant little idiomorphic augites, magnetite, many needles of apatite, and a colourless isotropic base, which is here in rather larger amount. This rock evidently belongs to the 'pyroxenites' of Doelter, which Rosenbusch more conveniently terms 'augitites,' the former name being preoccupied by a very different group of rocks. As in the limburgites, Doelter (op. cit., pp. 137–143) distinguishes two kinds, one having a brown glassy base and the other a colourless base, assumed to be also glassy.

The dykes mentioned by Darwin (p. 3) as intersecting these lavas seem to be of related types, but the only one sliced [4713] shows some differences. Augite preponderates over olivine among the porphyritic crystals. The ground-mass, in addition to augite and magnetite, contains little slender crystals of felspar, some with twinning. It is noteworthy that most of these crystals give low extinction-angles. There is an interstitial base of brown glass. Notwithstanding the presence of some felspar, the affinities of this rock are decidedly with the limburgites rather than the basalts.

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[1] The common English spelling is here adopted. Darwin writes the name 'St. Jago,' and Doelter uses the Portuguese form 'S. Thiago.'

The calcareous deposit calls for no remark. The white balls, mostly from one to two inches in diameter, built up by 'Nulliporæ,' are interesting as the analogue, on a giant scale, of a certain type of oolite. The alteration in the upper part of the calcareous deposit, where it is overlain by the younger lavas ("Volcanic Islands," pp. 5, 6), is probably due to solution and recrystallization at least as much as to metamorphism. Darwin's explanation of the curious intermingling of carbonate of lime and lava here, and again at Red Hill (pp. 10–14), will scarcely be accepted at the present day. He believed "that the lime has been erupted, mingled with the molten lava." His specimens seem to show merely a breccia of pieces of dark lava in a calcareous matrix, and again calcite and aragonite crystallized in the vesicles and interstices of a scoriaceous lava. This is also the opinion which Doelter formed on the spot.

The lavas which overlie the calcareous rocks of the coast district (pp. 9, 10) are, judging by the specimens, poorer in conspicuous phenocrysts than the lower lavas. Usually some small olivines are the only element visible to the naked eye. The compact ground-mass has not the uniformly dark colour of the lower lavas, but is often mottled or streaked with lighter and darker shades of grey. A thin slice of one example [4703] shows small crystals of the usual olivine, pale augite, and magnetite, the olivine being largely replaced by pseudomorphs of a deep red-brown colour. In addition, there are small crystals of felspar with twin lamellation and low extinction-angles. There is finally an abundant isotropic base, quite colourless, enclosing very numerous slender needles of apatite. This colourless base is partly segregated into little patches and streaks relatively free from the crystallized constituents (except apatite), and in these places it shows unmistakably the cubic cleavage characteristic of analcime. The rock may therefore be styled an *analcime-basalt*, allied to monchiquite, the presence of some felspar being the only character distinguishing it from typical monchiquites.

In speaking of the lower lavas, the nature of the colourless isotropic base in the second and third types was left in doubt, its strictly interstitial occurrence making its identification a matter of difficulty. In the rock now considered, although isolation and chemical analysis are desirable to give confirmatory evidence, there can be no reasonable hesitation in recognizing the colourless substance as analcime; nor is there any reason to question its status as a primary constituent of the lava. How far a like interpretation may be applicable to 'limburgites' and 'augitites' with colourless base in the Cape Verd Isles and elsewhere, it would be rash to venture an opinion. If the colourless base in the rocks described above can be regarded as analcime, then [4705] may be named a *monchiquite*, and [4706] a monchiquite without olivine, or, according to the distinction made by J. F. Williams, a *fourchite*.

The lavas of Signal Post Hill[1] ("Volcanic Islands," p. 15) are again of monchiquitic affinities. One fresh example has been sliced [4711]. It is a dark-grey rock of compact texture, enclosing abundant olivine, which is partly red from incipient change. Different stages of the process of alteration are shown by other specimens, the final product being the "dark jasper-red earthy mineral," with "indistinct cleavage," described by Darwin in a footnote. It is one of the variable and imperfectly-known alteration products of ferriferous olivine to which iddingsite and several allied substances belong. The slice shows the olivine here to be only slightly altered. As usual in these rocks, its crystals are sharply formed, as are those of the less plentiful augite. The latter mineral is very pale brown, with the zonary banding well marked between crossed nicols and sometimes assuming the hour-glass arrangement. There are also grains of black iron-ore and a few small flakes of biotite. The ground-mass is composed of numerous little crystals of augite and magnetite, with interstitial clear analcime and the usual apatite needles. The rock may be named a *monchiquite*. Another sliced specimen from the neighbourhood of the same hill [4712] is closely similar to the preceding, but the colourless interstitial matter shows some difference. For the most part it is isotropic, and may probably be set down as analcime, though the cleavage is not so evident as in the other slice. There are, however, patches, not distinguishable from the rest in natural light, which are birefringent, and are probably nepheline. It may be recalled that this mineral is found occasionally in the original monchiquites of Brazil.

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[1] 'Flagstaff Hill' in Catalogue; 'Mte. Facho' according to Doelter.

The "inland hills of more ancient volcanic rocks" have not furnished many specimens to Darwin's collection, and none of these have been sliced. Fresh examples from the "upper strata" are dark compact rocks enclosing abundant little grains of olivine, and they may be allied generally to the limburgites and monchiquites, though in one case a few slender crystals of felspar are just discernible. The specimens from the "basal strata" are not fresh enough to be diagnosed, and are of close texture without visible crystals. They have a yellowish-white colour, with ferruginous staining, and it is possible that they are, as Darwin supposed, of trachytic nature, though Doelter found no true trachytes in the Cape Verd Isles.

Several specimens are described in the Catalogue as "various crystalline rocks forming more central part of island," and are stated to come from north-west of Porto Praya, without closer specification. They evidently belong to the same group of lavas as those found in the coast district, and may be from some of the same flows. One example sliced [4707] is a *limburgite* like the one described above from Quail Island [4704], except that the brown glass is here more abundant than in the former case, and encloses only a few minute crystals of magnetite instead of the abundant skeleton growths. Another specimen [4708] is not very different. The porphyritic elements are the same as before, except that the olivine is now replaced by carbonates. In the ground-mass, besides the little crystals of augite, there are others of felspar, giving moderate extinction-angles, and the interstitial base is the usual deep brown glass of the limburgites.

A specimen from the precipice surrounding the village of S. Domingo ("Volcanic Islands," footnote on p. 20) shows the usual abundant crystals of olivine set in a dark compact ground-mass, but a thin slice [4714] brings out certain differences. The olivine crystals are transformed, marginally or sometimes totally, into a deep red-brown mineral, having a high birefringence comparable with that of the olivine but with oblique extinction. There are also a few small flakes of biotite in the rock. The general ground-mass shows abundant minute crystals of augite, with some of magnetite, in a colourless base, enclosing very abundant needles of apatite. The base is in part isotropic, doubtless analcime, but largely of a birefringent mineral, which seems to be felspar rather than nepheline. Much of it has the appearance of sanidine. In places, however, the interstitial material has segregated out into relatively large clear patches, and these consist partly of analcime, partly of a lamellated plagioclase with low extinction-angles.

It appears from the foregoing notes that the prevalent types of lavas in the southern part of this island are of highly basic or ultrabasic composition, and belong principally to the limburgite-monchiquite group, though including some aberrant varieties. There remain to be noticed the phonolites, which may perhaps be regarded as the leucocratic complements of the preceding. Darwin remarks that, among the trachytic-looking rocks which make the lower parts of the flat-topped hills inland from Porto Praya he found in three places "smooth conical hills of phonolite, abounding with fine crystals of glassy felspar, and with needles of hornblende" ("Volcanic Islands," pp. 19, 20). In the Catalogue two of the specimens are described as from 'paps' peeping up among the "various crystalline rocks" (limburgites, as we have seen) north-west of Porto Praya, and the third from "pap-like hills composed of vitreous felspar" north-east of Porto Praya. Darwin's account seems to imply, though not very clearly, that their relations are intrusive, but Doelter terms these little hills 'Kuppen.' The specimens show fresh crystals of sanidine, up to ½ inch in length, in a compact ground-mass of lighter or darker shades of grey, with the characteristic lustre imparted by abundant nepheline. While belonging to the *phonolite* family, they exhibit considerable variety of characters. The three specimens sliced illustrate as many different types, and they differ also from one described by Doelter[1] from the same neighbourhood.

In the first type of phonolite [4710] the porphyritic elements are sanidine and ægirine, with some crystals apparently of altered nepheline and a few octahedra of magnetite. The ægirine is green, with fairly marked pleochroism, and much of it occurs as aggregates of little crystals making pseudomorphs after larger crystals. The ground-mass, constituting the greater part of the rock, is composed of very abundant little crystals of nepheline with sanidine.

In the second type [4709] the porphyritic elements are more abundant, and include a greater variety of minerals. In addition to the large sanidines there are well-shaped crystals of nepheline, fairly numerous little dodecahedra of sodalite, turbid in the interior, abundant green pyroxene and deep brown melanite, and some rather irregularly-shaped crystals of pale sphene. The pyroxene is an ægirine-augite with strong pleochroism in bluer and yellower shades of green. The extinction-angle in vertical sections scarcely exceeds a value of about 30°. In one clinopinacoidal section the main part of the crystal gives 32°, while a border of rather deeper colour gives 27°. The ground-mass of the rock, with well-pronounced flow-structure, is composed of sanidine, nepheline, and a pyroxene, apparently ægirine, while slender needles of apatite are seen in places.

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[1] Op. cit., pp. 88–91, with chemical analyses. The word 'nephelinarmen' at the beginning of the description should be 'nephelinreichen.'

The third type of phonolite [4715] differs from that last described in carrying hornblende. The sanidine, nepheline, sodalite, ægirine-augite, and melanite are present as before, and the ground-mass is of nepheline, sanidine, and ægirine, with fluxion-structure. The hornblende crystals are idiomorphic, usually twinned, and in colour from brownish-green to greenish-brown in the thin slice. They have been corroded by magmatic resorption, the product of this reaction being green ægirine-augite, which mineral also occurs separately in small idiomorphic crystals. It appears probable that the aggregates of ægirine crystals noted in the first type [4710] have likewise been formed at the expense of hornblende, the transformation in that case being complete. It may further be enquired how far the seemingly independent crystals of pyroxene in these rocks may be due to the breaking-up of such aggregates, which originated as resorption-pseudomorphs after hornblende.[1] If there be any truth in this suggestion, Doelter's distinction between augite-phonolites and hornblende-phonolites may perhaps mark no very essential difference. It is noteworthy that, in the phonolite from this neighbourhood which he studied, the two generations of pyroxene were found to differ greatly in composition, the one being an augite containing but little soda, and the other apparently an acmite or ægirine with a remarkable content of manganese.

The tephrites, basanites, felspar-basalts, and nepheline-basalts recorded by Doelter from various parts of the island of Santiago do not seem to be represented in the "Beagle" collection, so far as can be judged from megascopic characters; and the prevalent types in the district of Porto Praya are doubtless fairly illustrated by the specimens which we have selected for examination.

III.—THE RELATION OF THE CONCRETIONARY NODULES OF THE YARRA TO THE CALCAREOUS NODULES KNOWN AS 'COAL-BALLS.'

By M. C. STOPES, Ph.D., D.Sc., Lecturer at Manchester University.

SPHEROIDAL concretions from the Yarra estuary which were found to contain plant-remains were described by Mr. Chapman recently in this journal.[2] The structures in themselves are of considerable interest to geologists, and also to palæobotanists from the fact that they contain "matted fragments of woody and foliaceous material." They were made the subject of some comparisons with the calcareous concretions from the Lancashire Coal-measures, and as a result certain general considerations were brought forward, which call for comment, and which are of sufficient importance to receive attention.

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[1] A like question has been raised by Washington with reference to the augite-grains in many hornblende-andesites: Journ. Geol., vol. iv (1896), pp. 273–278.

[2] F. Chapman, "On Concretionary Nodules with Plant-Remains found in the Old Bed of the Yarra at S. Melbourne; and their Resemblance to the Calcareous Nodules known as 'Coal-Balls'": GEOL. MAG., December, 1906, p. 553.

In the first place, the comparison which Mr. Chapman made between the Yarra concretions and the English 'coal-balls' is hardly justified by the facts when they are carefully considered. By those who have a practical acquaintance with the English Coal-measures the 'coal-balls' or calcareous concretions which are found actually *in* the coal itself are at once recognised as being very different in their nature, formation, and occurrence from the clay ironstone or clay nodules which are found widely distributed in the various beds of the Carboniferous, and which also contain fragments of plants in many cases. Yet, though it is with the latter that the Yarra concretions more nearly approximate, it is to the former that Mr. Chapman has compared them. Nevertheless, he calls them 'clay nodules,' and describes the clayey nature of their outer layers, and states that under microscopic examination the matrix "was seen to consist of quartz-grains, fine calcareous and argillaceous particles, brown woody tissue, and valves of the marine diatom *Actinocyclus*." Further, the residue from the nodule was shown, after treatment with H Cl, to consist of "a fine angular quartz sand, the grains of which have a diameter varying generally between ·1 mm. and ·018 mm. Some tourmaline and zircon crystals were also present." None of which things, to my knowledge (except the woody tissue and the calcareous matter), are in the least characteristic of the true 'coal-balls,' which are singularly free from such materials. Of the coal-balls I have examined many hundreds, both *in situ* and in the laboratory, and have also followed the results of the many analyses which have been done for the special work I have been undertaking.

Mr. Chapman continues:—"From the occurrence of the nodules on the sides of the old river channel, and seated in depressions, we may reasonably assume that they received their form in 'kettles' or 'potholes' in the clay bottom of the river bed." These facts, again, are fundamentally opposed to those that hold for the Yorkshire and Lancashire 'coal-balls,' which occur neither in old river channels nor in 'kettle' depressions, but are found in a normal seam replacing the coal in local patches, in which the stratification of the coal round them is regular and undisturbed, and shows none of the 'swirling eddies' suggested by Mr. Chapman for the cause of the rounded form of these concretions. When Mr. Chapman enters into the theory of their mode of formation he reveals that he is seriously hampered in this attempt by want of facts and an intimate knowledge of the actual details of the case of the Lancashire and Yorkshire 'coal-balls.'

Though superficially the Yarra concretions and those of the English coal-seams may appear to be similar structures, yet I think that enough has been said to show that they are of fundamentally different construction and mode of origin.

The Yarra concretions being formed as they are of clayey masses surrounding fragments of plants are, however, directly comparable with the clay concretions and clay ironstones which are constantly found in the English Coal-measure beds, and which have also yielded many valuable specimens of fossil vegetables. These, however, are in no way comparable with the true 'coal-balls,' which are a formation as unique and as characteristic as any structure in the range of geology.

That it is "worth a further enquiry" into the theories of formation of the English coal-balls, is a conclusion with which one can heartily agree with Mr. Chapman, even while controverting his original premises, and I may add that during the last few years, assisted by the Royal Society and in conjunction with Mr. Watson, I have been undertaking work of an extensive and detailed nature on the subject. The results of this work all point to the truth of the *in sitû* theory for the coals in which the true 'coal-balls' are found, and in a full paper we hope to set forth the many and various facts which support this statement. It must not be forgotten, however, that the coals in which these structures occur are in many ways rather special cases, and show certain characters which are almost unique, so that "the evidence already known, which goes to prove an allochthonous origin for much of the coal-deposits of various ages in different parts of the world," does not affect the question. Geology is now sufficiently advanced to recognise that there may be two or more modes of formation for the various coal-seams. When structures so characteristic and so unique as the true calcareous 'coal-balls' occur in a seam, it is but natural to be prepared to find that some rather unusual conditions were associated with the deposition of that coal.

To conclude. It appears that in the facts of importance in their structure and origin the Yarra nodules do not resemble the calcareous nodules known as 'coal-balls,' and that therefore conclusions as to the origin and occurrence of the latter based on a comparison with the former must inevitably be fallacious. The Yarra concretions are none the less interesting, and may be compared with other concretionary structures in the Carboniferous with great advantage.

IV.—SEDGWICK MUSEUM NOTES.

CRUSTACEA, ETC., FROM GIRVAN.

By F. R. COWPER REED, M.A., F.G.S.

(PLATE IV.)

THE numerous and full accounts of the Crustacea (apart from trilobites) from the Girvan area which Professor Rupert Jones, Dr. H. Woodward, Mr. R. Etheridge, jun., and others[1] have published during the last three or four decades may seem to render any further remarks by me superfluous. But at Dr. Henry Woodward's suggestion Mrs. Gray recently sent to me some fresh material for examination, which, in addition to yielding some new species, throws some interesting

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[1] Peach: Proc. Roy. Phys. Soc. Edinburgh, vol. xiv (1902), Session 1900–1901, Pres. Add., p. 369.

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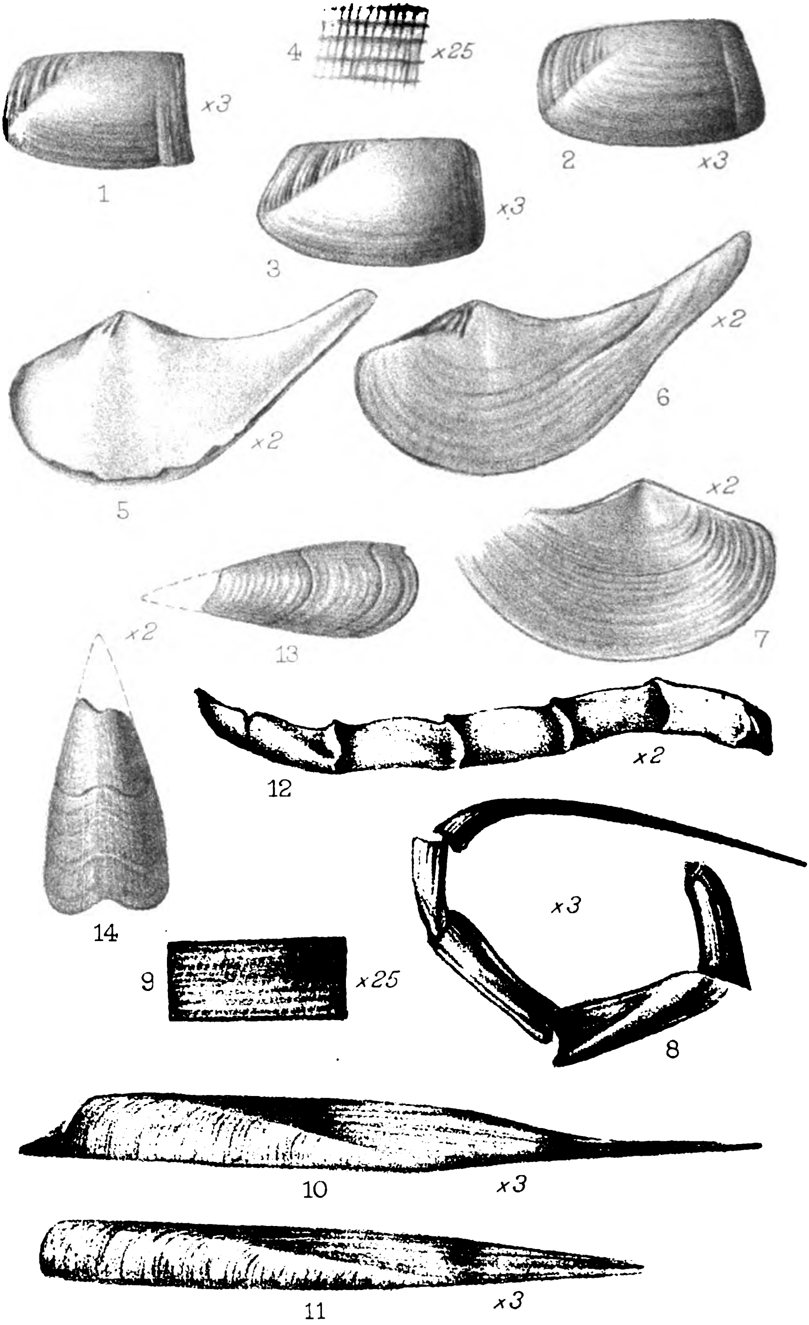

G. M. Woodward del. et lith.　West, Newman imp.

Crustacea &c from Girvan.

light upon previously described forms, and permits some further details to be added to our knowledge of them.

ANATIFOPSIS BALCLATCHIENSIS, sp. nov. (Pl. IV, Figs. 1–4.)

Diagnosis.—Valves oblong, about 1⅔ times as long as high, longer along ventral than dorsal margin, narrower in front than behind, transversely gently convex (in a dorso-ventral direction). Dorsal margin nearly straight or gently arched. Anterior end narrowed slightly, obliquely truncated in front, obtusely pointed below. Ventral margin decidedly convex, longer than dorsal. Posterior end straight, truncated abruptly and nearly at right angles to dorsal edge, with narrow marginal raised rim, and a fairly strong narrow straight groove parallel to margin and at a short distance from it, followed behind by a few finer parallel impressed striæ. From the inferior angle of the anterior end, a rather strongly impressed straight diagonal line traverses the valve, meeting the dorsal edge a little in front of its middle length and thus cutting off a triangular area on the surface. Below and behind this impressed line the surface is ornamented with longitudinal raised lines or fine lamellæ, parallel to the ventral margin; these lamellæ, on crossing the diagonal line, bend up suddenly to run parallel to the anterior end of the valve, and at the same time increase somewhat in strength. A delicate transverse lineation at right angles to the longitudinal lines and between them is visible in well-preserved specimens.

Dimensions:

	I.	II.
Length	8·0	9·5 mm.
Height (at posterior end) ...	5·0	6·0 mm.

Horizon and Locality.—Balclatchie Beds, Balclatchie, Girvan.

Remarks.—In 1895 Professor Rupert Jones and Dr. Henry Woodward[1] briefly described and figured an imperfect fossil from Balclatchie, which they doubtfully referred to the lamellibranch genus *Cypricardinia*, remarking at the same time that in one position it had somewhat the appearance of a broken portion of a *Pinnocaris*. Mrs. Gray has recently submitted to me this specimen and over a dozen more, some of which are much better preserved than the type. On further investigation of these fossils and comparison with Barrande's *Anatifopsis bohemica*[2] of Etage D*d* 3 – *d* 5, I am convinced that they must be referred to this genus, whatever its true position amongst the Crustacea may be. Our specimens bear a very close resemblance to the one figured by Barrande in fig. 36, pl. xxvi (op. cit.), and possess all the essential characters of the genus. It is interesting to observe that Barrande himself stated that Wyville Thomson had discovered a fossil similar to *Anatifopsis* in the South of Scotland.

Nearly all our specimens are of left valves, as Barrande also remarks is the case in *A. bohemica*.

The peculiar transverse grooves or grooves at the posterior end of the valve are interpreted by Barrande as thoracic segments; but if so,

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[1] Jones & Woodward: GEOL. MAG., Dec. IV, Vol. II (1895), p. 542, Pl. XV, Figs. 4*a*, 4*b*.

[2] Barrande: Syst. Silur. Bohême, vol. i, suppl. (1872), p. 578, pl. xxvi, figs. 36–41.

they are completely fused with the cephalic shield, and the presence of free segments behind is conjectural. Indeed, the genus has been placed by some palæontologists amongst the Cirripedes, and it is possible that it is really allied to *Lepas*. The dorsal edge of the valves is never well seen, but is more incurved than the ventral.

There is a somewhat longer and narrower form of valve represented at Balclatchie, with the dorsal and ventral margins straighter and nearly parallel, but otherwise possessing precisely the same characters as the above, so far as can be seen in the two imperfect examples before me. It probably belongs to another species, and bears much resemblance to the insufficiently known *A. longa*, Barrande (op. cit., p. 579, pl. xxvi, figs. 42–45).

PINNOCARIS CURVATA, sp. nov. (Pl. IV, Figs. 5–7.)

The single species of this peculiar genus hitherto known was first described[1] by R. Etheridge, jun., from the Balclatchie Beds of the Girvan district, but was subsequently treated more fully by the same author in conjunction with Professor Nicholson in their "Monograph on the Silurian Fossils of Girvan," vol. i, 1880, pp. 207–210, pl. xiv, figs. 17–20. Since then Professor Rupert Jones and Dr. Henry Woodward have discussed it on two occasions[2] and published figures and accounts of the Balclatchie specimens in Mrs. Gray's collection, and of one English example from the Upper Silurian of Kendal.

There are seven specimens of a member of this genus, from the Starfish Bed, Drummuck Group, of Thraive Glen, which Mrs. Gray has sent me for examination. The horizon is new, and the characters of the fossil are such as to warrant its specific separation from the Balclatchie form which was named *P. Lapworthi*. The name *curvata* may be proposed for it on account of its peculiar shape.

Diagnosis.—Carapace bivalved. Valves flattened, triangularly obovate and elongate, posteriorly curved upwards; anteriorly broad, widening to middle of valve, then tapering rapidly into long narrow produced posterior portion. Pseudo-umbo situated at about one-third the length of the shell from anterior end. Dorsal margin in front of pseudo-umbo obliquely inclined downwards, slightly concave, thickened internally; margin behind pseudo-umbo curved, markedly concave upwards. Anterior margin short, regularly rounded, semi-elliptical. Ventral margin strongly convex to a little behind middle of valve, then curving rapidly upwards and slightly concave. Posterior portion of valve narrow, elongate, tapering to blunt end, gently convex, not corded, but marked with weak submedian groove along its length. Surface of valves marked with regular striations concentric to ventral margin, centreing on pseudo-umbo, and ending abruptly against pre-umbonal dorsal margin. In internal casts there is in each valve a short slit proceeding obliquely forwards from the umbo at a small angle to the margin, and immediately in front of it is another but weaker slit, or rather groove, making a smaller angle with the margin. These slits represent short ridges in the interior of the valves.

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[1] R. Etheridge, jun.: Proc. Roy. Phil. Soc. Edinb., vol. iv (1878), p. 167, pl. ii, figs. 3–5.

[2] Jones & Woodward: Mon. Brit. Palæoz. Phyllocarida (Palæont. Soc.), pt. ii (1892), pp. 118, 119, pl. xv, fig. 24; id., GEOL. MAG., Dec. IV, Vol. II (1895), pp. 542–545, Pl. XV, Figs. 5–10.

Dimensions:

	A.	B.	C.
Length	30·5 ...	26·0 ...	15·50 mm.
Width	13·0 ...	12·0 ...	6·25 mm.

Remarks.—This species differs from *P. Lapworthi* in the curved form of the shell, the posterior part being strongly bent up, and the dorsal margin concave instead of straight and apparently not corded. The anterior end is also narrower, and the posterior portion relatively shorter. The pre-umbonal ridges are a special feature, and suggest doubts as to the reference of this fossil to the Crustacea. One of our specimens (c) shows both valves of the carapace on counterpart slabs of rock, and from it we are able to see that the posterior elongation of the shell forms by the juxtaposition of the two valves a narrow laterally compressed tube.

PINNOCARIS LAPWORTHI, Etheridge, jun.

In addition to some excellently preserved examples of this species in the Sedgwick Museum from the type locality Balclatchie, Mrs. Gray's collection contains some from the same beds at Dow Hill and Ardmillan; and another specimen from the higher beds of Shalloch Mill is scarcely to be distinguished from this species, but its state of preservation makes its determination a little uncertain.

DIPTEROCARIS (?) sp.

There is one imperfect right valve from Ardmillan in Mrs. Gray's collection which appears to be identical with the form from Penwhapple Glen which was described and figured by Messrs. Nicholson and Etheridge[1] as *Peltocaris* sp., but which Professor Rupert Jones and Dr. Woodward[2] believe may belong to the American genus *Dipterocaris*, Clarke. Apart from the new locality and horizon there is nothing further to learn from our specimen.

SOLENOCARIS SOLENOIDES, Young. (Pl. IV, Figs. 8, 9.)

The fossil described in 1868 by Messrs. Young[3] as *Solenocaris solenoides* was referred by Professor Rupert Jones and Dr. Henry Woodward[4] in 1885 to the genus *Helminthochiton*. The specimens figured by these authors, together with some fresh material from the same locality, Balclatchie, have been submitted to me by Mrs. Gray, and a recently acquired specimen in the Sedgwick Museum has also been examined. There would be nothing further to add to the description of the species already published if it were not for the presence of one important specimen in Mrs. Gray's collection, which shows four consecutive segments of the body (and a trace of a fifth) possessing the typical characters (see Woodward's figure, op. cit., pl. ix, fig. 11), but which are followed by a long styliform appendage

[1] Nicholson & Etheridge: op. cit., p. 212, pl. xiv, fig. 21.

[2] Jones & Woodward: Mon. Brit. Palæoz. Phyllopoda, p. 112, footnote.

[3] Young: Proc. Nat. Hist. Glasgow, vol. i (1868), pt. 1, pp. 171–173, pl. i, figs. 7*a*, *b*.

[4] Jones & Woodward: GEOL. MAG., Dec. III, Vol. II (1885), p. 356, Pl. IX, Fig. 11.

recalling the caudal style of *Ceratiocaris*. The four segments and the style seem to belong to one and the same individual, and are curved round into a rough circle so that the style overlaps and crosses the first of the segments. The style has been slightly displaced, but seems to articulate with the last segment, though it is placed at what Messrs. Young considered the anterior end of the plate. It has the usual elongate slender triangular shape of a caudal style of *Ceratiocaris*, and tapers gradually to a point, though the latter is hidden by matrix. In length it is at least three times that of the last segment; it is slightly curved at the base, which is rounded, truncate, and slightly swollen, and the surface is longitudinally striated and very minutely granulated, the granules being arranged in transverse linear series, giving the appearance of fine transverse striation. Young mentions a similar fine granular ornamentation on the plate of the type-specimen of *Sol. solenoides*.

There are also in Mrs. Gray's collection two elongated segments of probably the same species, but from Dow Hill and Ardmillan respectively; they are much longer and narrower in proportion than the Balclatchie segments, one measuring 10·25 mm. long by 2 mm. wide at the anterior end, and the other 9 mm. by 1·75 mm.; they decrease slightly in width posteriorly, otherwise they agree in characters and ornamentation with the typical examples from Balclatchie.

In the face of this new evidence it may be well to hesitate to refer this fossil to the genus *Helminthochiton*; and with the suspicion that it may ultimately have to find its place amongst the Phyllocarida we may return to the old generic name *Solenocaris*[1] without committing ourselves to any final decision on its affinities.

The main points of distinction between the Balclatchie form *S. solenoides*, and the one from the Upper Bala beds of Penwhapple Glen and Thraive Glen known as *Helminthochiton Grayiæ* have been pointed out by Professor R. Jones and Dr. Woodward, and need not be here repeated. But it may be added that in *Sol. solenoides* the longitudinal ridges below the diagonal ridge are parallel and straight, and meet the diagonal at a very acute angle, whereas in *H. Grayiæ* they curve up to meet the diagonal at nearly a right angle. The plates of the former also are covered with a shining black chitinous substance, as is the case with Crustacea from the same bed, whereas this covering is absent from the plates of *H. Grayiæ*, and they seem to be composed of a calcareous material, and are altogether thicker and stouter in substance.

Dimensions of figured specimen showing four segments and style :—

Length of segments	7·0–5·5 mm.
Height of ditto	3·0–2·5 mm.
Length of style	+ 14·5 mm.
Estimated total length of ditto	18·0 mm.
Width of spine at base	2·0 mm.

CERATIOCARIS (SOLENOCARIS?) sp. (Pl. IV, Figs. 10, 11.)

There are several specimens from Balclatchie in the Sedgwick Museum similar to the style-like body accompanying a specimen of

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[1] Nicholson & Etheridge: Mon. Silur. Foss. Girvan, fasc. i (1878), p. 207.

Pinnocaris Lapworthi figured by Jones & Woodward.[1] When only the broader part is preserved they resemble *Hyolithes*, but it is found that the apex is prolonged into a slender spine of greater or less length in complete specimens; and they possess a black shining chitinous (?) shell like *Solenocaris solenoides*. In Mrs. Gray's collection there is one from Dow Hill measuring 34 mm. long and 3 mm. wide at its base, and another measuring a little over 30 mm. long. The flattened broader part, which is equal to about half the length of the whole style, tapers very slightly, has a rounded or truncate base, and is marked with a faint diagonal ridge, above which are weak longitudinal ridges or striæ, and below which are fine regular transverse striæ curving forwards a little to meet the diagonal. The spine is slender and rounded, and scarcely tapers at all from its base. Occasionally the whole basal portion of the style is crossed by the transverse striæ, and the diagonal and longitudinal lines seem absent; and probably we here see the inferior face of the spine, if it was triangular in cross section.

HELMINTHOCHITON GRAYIÆ, H. Woodward. (Pl. IV, Fig. 12.)

The species was minutely described on the evidence of two pieces of the same individual, and its affinities were discussed by Dr. Henry Woodward in 1885.[2] Further specimens, numbering thirteen in all, from the same locality, Thraive Glen, have been recently sent to me for examination by Mrs. Gray: ten of these are marked as coming from the Starfish Bed; four of them consist of internal casts and external impressions of two nearly perfect (?) individuals, one being as complete as the type, consisting of seven plates, and the other, though broken, showing the impression of six segments. In another impression of the outer surface from Thraive Glen there are seven plates distinctly present, though the terminal portions of the two end plates of the series are broken. Two other specimens from the Starfish Bed, each with one end imperfect, show only six plates. The other specimens are more fragmentary, or consist of fewer plates. However, from the evidence of the one from Thraive Glen we may conclude that there were at least seven segments in the organism, and we cannot feel certain that there may not have been several more. The specimen here figured from the Starfish Bed with six distinct segments has traces of a seventh at the larger (anterior ?) end, which is bent sharply down into the matrix; the other (posterior) end is narrower and slightly curved upwards, and the sharp dorsal ridge is produced into a distinct terminal short spine, the posterior margin of the plate not being abruptly truncated nearly at right angles (as in the others) but sloping up obliquely to meet the spiniform prolongation of the dorsal ridge at an angle of about 30°. In all the plates there seems to be a short pointed process at the posterior end of the dorsal ridge, overlapping the succeeding plate.

In two of the specimens from Thraive Glen the shell is preserved, and there seems to be on these plates, as in the external impressions from the Starfish Bed, a minute linear granular ornamentation on the ridges parallel to the inferior border.

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[1] Jones & Woodward: GEOL. MAG., Dec. IV, Vol. II (1895), p. 544, Pl. XV, Fig. 5a.

[2] Woodward: GEOL. MAG., Dec. III, Vol. II (1885), p. 352, Pl. IX, Figs. 7–10.

The anterior, shorter, more rounded plate, which Dr. Woodward describes in the type as probably the cephalic plate, does not seem to be preserved in any of the new specimens. Our figured specimen, which measures just 40 mm. when we straighten out its curved body, has the first perfect plate at the anterior end measuring 8·5 mm. in length; the succeeding three are of nearly the same length, but the fifth one is only 5·5 mm. long, and the terminal one only 4 mm. The height of the plates decreases gradually from about 5 mm. at the anterior end to 2 mm. at the caudal extremity. The ornamentation, having been carefully figured and described by Dr. Woodward, calls for no further remarks. Unfortunately the new material does not throw any fresh light on the affinities of the fossil, but the discovery of a long caudal style in *Solenocaris solenoides*, which in so many respects resembles *H. Grayiæ*, makes us feel somewhat less certain about its true zoological position.

CHITON sp. (Pl. IV, Figs. 13, 14.)

There is one specimen in Mrs. Gray's collection from the Saugh Hill Group of Woodland Point, Girvan, which must be referred to the genus *Chiton*, and in some respects bears a resemblance to the only Silurian species which has been described, *Ch. grayanus*, De Koninck.[1] Our specimen consists of two consecutive segments in contact, the whole forming a conical body about 17 mm. long, tapering anteriorly at an angle of about 20° to a pointed end; it is strongly convex, but not dorsally keeled, the plates being arched down regularly on each side from the rounded dorsum. The anterior plate (broken in front) is of an acutely triangular shape, measuring about 9 mm. in length, 4 mm. in height, and 6·75 mm. in width at the base; the posterior margin has a sinuous outline, being excavated in the centre, curved back at the sides to form the apophyses, and then sharply curved forwards to the inferior margin. The second plate is transversely subrhomboidal, and at first seems to consist of two fused plates, owing to a deep groove across it behind its middle which is due to a suspension of growth, as De Koninck described and figured in *Ch. grayanus*. It measures about 7·5 mm. in length, 5 mm. in height, and 8·75 mm. in basal width. Its posterior margin has the same sinuous outline as its anterior edge.

Each plate has the shell preserved, except near the point of the anterior segment, and shows concentric growth-striæ parallel to the sinuous margin, with some faint diagonal striæ on the sides radiating from the front end of the first segment and crossing both segments impartially; there also appears to be a fine granulation present.

The nearest ally of this form is certainly *Ch. grayanus*, but the pointed anterior plate is quite different to the subcircular one conjectured by De Koninck for the latter.

From the Middle Bala of Shalloch Mill Mrs. Gray has obtained one isolated imperfect plate of a *Chiton*, in which the sides are bent down rather more acutely and suddenly leaving a narrower dorsum, but the ornamentation and general shape appear to be indistinguishable from the Llandovery form above described.

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[1] De Koninck: Bull. Acad. Roy. Sc. Belgique, ser. II, vol. iii (1857), pp. 190–199, pl. i; transl. W. H. Baily, Ann. & Mag. Nat. Hist., ser. III, vol. vi (1860), p. 96, pl. ii, figs. 1*a*–*d*.

EXPLANATION OF PLATE IV.

Fig. 1.—*Anatifopsis balclatchiensis*, sp. nov. Left valve. × 3. Balclatchie Beds: Balclatchie.
„ 2.—Ditto. Ditto. × 3. Same horizon and locality.
„ 3.—Ditto. Ditto. × 3. Same horizon and locality.
„ 4.—Ditto. Ornamentation of surface. × 25.
„ 5.—*Pinnocaris curvata*, sp. nov. Left valve. × 2. Starfish Bed: Drummuck Group, Thraive Glen.
„ 6.—Ditto. Ditto. × 2. Same horizon and locality.
„ 7.—Ditto. Anterior portion of right valve, showing ornamentation. × 2. Same horizon and locality.
„ 8.—*Solenocaris solenoides*, Young. Posterior four segments with caudal spine attached. × 3. Balclatchie Beds: Balclatchie.
„ 9.—Ditto. Ornamentation of surface of spine of same specimen. × 25.
„ 10.—*Ceratiocaris* (*Solenocaris?*) sp. Caudal spine. × 3. Balclatchie Beds: Dow Hill.
„ 11.—Ditto. Ditto. × 3. Same horizon and locality.
„ 12.—*Helminthochiton Grayiæ*. H. Woodward. Internal cast of portion of body, showing the seven posterior segments. × 2. Starfish Bed: Drummuck Group, Thraive Glen.
„ 13.—*Chiton* sp. Side view. × 2. Saugh Hill Group, Woodland Point.
„ 14.—Ditto. Same specimen, top view. × 2.

V.—Deformation and Variation in the Sea-Level.[1]

By H. W. Pearson.

CHANGES in the relative level of sea and land along the oceanic borders of the globe seem to have been in continual progress during the entire historic period. Too slow and gradual for direct observation, they can only be detected through comparison of ancient with modern maps, records, or statements. This comparison has now, in hundreds of cases, been made, and it is well established that stability of coastline is the exception, movement of elevation or depression the rule. In one region, it has been observed, the sea for long periods of time has been in continual retreat; at another location it has been long advancing over the land, while at some third point it seems to have remained fixed in position.

In the days of Linnæus and Celsius, when the uplift of the Baltic shores was first recognized, it was believed that this motion could be best explained by assuming an actual depression, or falling, in the surface of the sea, but since the time of Playfair this idea has been entirely abandoned, and all authorities now hold that these motions must be due to movement in the crust of the earth.

Playfair's law, which has thus remained in possession of the field, has recently been restated by Professor Fairchild in the 5th edition of Leconte's "Elements of Geology" (p. 145), as follows:—"But by the principle of hydrostatic level, it is clearly impossible that the ocean should rise or fall *permanently* at one place without being similarly affected everywhere. It is certain, therefore, that the changes we have described above, being in different directions in different places, must be due to movements of the solid crust."

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[1] For former paper, see Geol. Mag., 1901, pp. 167, 223, and 253.

It seems that the conclusion above reached, based upon an argument first advanced about a century since, yet remains unchallenged. The position assumed, at first glance, appears logical, plausible, and unassailable. Nevertheless, there are certain considerations arising from facts of recent development that should induce us to examine this problem anew.

It will be seen that the entire weight of the above-mentioned argument is contained in the assumption—"It is absurd to assume a rise of the sea-level in one place and a fall in another at the same time" (Huxley, Physiography, p. 211); and if we find this position to be in error the long-adopted principle of Playfair must be held no longer tenable.

In opening this question anew, let us first give consideration to Mr. William Ferrel's law of deformation of sea-levels by ocean currents, contained in *Science*, vol. vii, p. 76. In this paper it is shown that oceanic currents impinging upon a shore-line have a tendency to *elevate*, those flowing away from a shore-line have a tendency to *depress*, the surface-level of the adjoining waters. A table is also given by which the amount of this deformation in any given latitude may be determined when the rate and direction of flow are known. By application of this table, and with the most conservative estimate that the Gulf Stream is flowing poleward at the rate of but four miles in twenty-four hours, Ferrel shows that the waters adjoining New York would be depressed about 5 feet below, and the waters adjoining Liverpool elevated 5 feet above, the normal sea-level, through the disturbing effect of the waters' flow. This total difference of 10 feet in elevation, however, he estimates will be cut down about one-half from the effects of under-currents impelled by the differing hydraulic heads above mentioned. His net result, therefore, is to find the waters around France and the British Islands elevated some 2½ feet above, and those around New York depressed some 2½ feet below, the normal level of the sea.

The values above reached, however, seem much smaller than the actual current velocities will warrant. Data from the papers and charts of the U.S. Hydrographic Office and the English Admiralty give results at least double or treble the value of four miles in twenty-four hours assumed by Ferrel. We must consequently conclude the waters adjacent to the British Isles to be elevated some 5 to 7 feet above the normal oceanic surface.

To the north of England the current is compelled to a more northerly course. This change in direction, combined with the effect from the more rapid shortening of the cosines of these latitudes, seems to make necessary on the coast of Norway a still greater rise in surface elevation than has already been determined for the coasts of England.

This writer, with data somewhat uncertain both as to direction and velocity, has reached results off the north coast of Norway calling for an elevation of over 20 feet in the surface-waters on these shores.

This amount, if reduced one-half by escaping currents as estimated by Ferrel, would still leave deformation of over 10 feet.

Applying in similar manner Ferrel's law to other ocean currents, we find deformation in sea-level to obtain on every coastline on the globe. Nowhere do we find a level surface. For instance, that current which in more northern regions becomes the Gulf Stream is first recognized somewhere south and west of Cape of Good Hope. At this latitude the surface of the earth is rotating to the east at a rate of about 790 miles per hour. At the Equator the rate of rotation is 1,040 miles per hour. These waters, therefore, before passing the Equator, must undergo an acceleration of some 250 miles per hour. Some of this acceleration will be obtained from impulse of the surrounding waters, some possibly from contact with the bottom, but the final acceleration must certainly be reached by the crowding of these waters against the entire eastern shore-line of South America, where deformation of level in the surface-waters must necessarily occur.

It follows, as a consequence, that a deformed and elevated water-surface must exist along the entire coastline of Brazil. Furthermore, we might infer that the south-flowing Brazilian current, like its prototype on the east coast of England, is an escaping, or secondary, current, impelled by the hydrostatic head in existence on those shores, as already suggested by Ferrel.

In the Gulf of Mexico an elevated surface is necessarily established by the united effect of the Equatorial and Gulf Currents. A gradually declining surface from Florida to Nova Scotia and Greenland should also be expected as we pass to the north, due to the retreat of the Gulf Stream from these shores. Some local elevation in the vicinity of the continental projections of Nova Scotia should also appear, from the uplifting effect of the south-flowing Labrador current.

On the European coasts a progressive rising gradient should be found from Africa northward to the shores of Nova Zembla.

Ferrel's law teaches us, therefore, that as long as ocean currents flow upon a rotating earth it is impossible to expect that confluent seas in differing latitudes, on any one coastline, should have the same absolute surface elevation.

It will now be observed that the magnitude of these deformations in oceanic surface as demanded by our law are such as to make their discovery almost a necessity. We are therefore justified in searching the records of levelling operations with the view of learning to what extent Ferrel's deductions may be confirmed by actual fact. Below we quote a few results arrived at from lines of precise levels, extended at different dates through Europe, the United States, and Canada. This list might be considerably enlarged, but the result would be invariably the same. All lines of level confirm Ferrel.

Precise levels in England indicate that "The sea-level of the northern part of the island generally is *higher* than that of the southern part." (U.S. Coast Survey Rep., 1874, p. 256.)

General Tenner found the Baltic Sea to be 0·53 fathom (3·18 feet) higher than the Black Sea. (This line through Russia.) (Smithsonian Report, 1890, p. 312.)

The Encyc. Brit., vol. xxii, p. 708, says: "Lines of level carried across the continent of Europe make the mean sea-level of the Mediterranean, at Marseilles and Trieste, from 2 to 5 feet below that of the North Sea and the Atlantic, at Amsterdam and Brest, *a result which is not easy to explain on mechanical principles*" (my italics).

In *Science*, vol. iii, the results from numerous lines of level in Europe are mentioned as follows:—Bourdalone in 1864 stated the average level of the Mediterranean to be 0·72 metre below that of the Atlantic. General Ibanez has shown the difference of level between Santander and Alicante as 0·66 metre, and between Marseilles and Amsterdam (through Alsace and Switzerland) as 0·80 metre.

Other differences are shown between the Mediterranean and North Sea as follows:—Through Prussian levels, 0·757 metre, *viâ* Alsace 0·809 metre, through Switzerland 0·832 metre, between Trieste and Amsterdam (*viâ* Silesia and Bavaria) 0·59 metre. (*Science*, vol. iii, p. 54.)

In *Science*, vol. vii, p. 75, we are told by Ferrel that the mean level of the harbour of Brest is 1·02 metre higher than the surface-level of Marseilles.

In the United States we find the same condition. Some twelve or fifteen lines of levels from various points on the Atlantic coast result invariably in determining the Gulf of Mexico to be elevated above the waters of the Greater Ocean.

Hilgard in 1884, from three sets of levellings, showed the Gulf at New Orleans as one metre higher than the Atlantic at Sandy Hook. (*Science*, vol. iii, p. 504.)

C. A. Schott shows that the difference of level between Sandy Hook and Lake Ponchartrain is 1·002 metre. (*Science*, vol. vii, p. 102.)

Mr. John F. Hayford, in Appendix No. 8 (U.S. Coast and Geol. Survey Reps., 1899, pp. 397–431), has shown that the average of six lines of precise levels run across Florida, from St. Augustine to Cedar Keys (1892, 1893, and 1894), gave as result the Gulf to be ·2585 metre above the Atlantic. He also shows that a line from Old Point Comfort on the Chesapeake to Biloxi, Miss., found the excess in surface-elevation of the Gulf to be 1·028 metre, and a series of levels from Sandy Hook to Biloxi—evidently not the same lines as those mentioned by Hilgard and Schott—resulted in a difference of ·385 metre. He furthermore gives an excess in the Gulf level of ·175 metre, arrived at by way of a line from Boston and New York to Lake Ontario, thence to Chicago and Duluth, and thence by a most circuitous course to the Gulf. The extraordinary length of this line, however, would seem to render its conclusions less trustworthy than the more direct lines previously mentioned.

In 1883 to 1886 the Canadian Department of Public Works caused a line of levels to be run from Quebec to Rouse's Point, N.Y., where a bench-mark of known altitude above mean sea-level at Sandy Hook had been established by the U.S. Engineers. The result of this line was apparently to establish the fact that the sea-level at Quebec was some 5½ feet *below* that of New York (5·52 feet). This determination was unexpected to this writer, as from the application of Ferrel's formula it would appear that the elevating effect of the southward-flowing

Labrador current, in immediate contact with the shore-line, would be much in excess of the depressing effect of the distant Gulf Stream. It seemed, therefore, impossible to explain mathematically this surprising lack of elevation in the St. Lawrence.

Such explanation, however, no longer seems necessary. In the Trans of the Can. Society of Civil Engineers for 1903, it has been shown by W. B. Dawson that the Admiralty datum at Quebec is 8·58 feet *below* mean sea-level, and that by reason of this the mean sea-level at Quebec had been assumed as about 8 feet too low. Mr. Sproule then pointed out—"This would imply that the observed sea-level in Quebec was 3½ feet *higher* than the sea-level at New York" (p. 124). Ferrel's deductions are thus again confirmed.

A rising gradient of exceptional magnitude is found in the line of levels run by Mr. Bunt in 1837 and 1838 from Portishead on the Bristol Channel, southward to Axmouth on the English Channel. This levelling was made at the instance of the British Association, and was one of the first attempts to introduce extreme accuracy into such labours. The result of nearly 9 inches excess in northern elevation, however, can hardly be ascribed entirely to the cause herein urged. Sir Charles Lyell (Principles, 9th ed., p. 295) has shown that "The rise of a tidal wave above the mean level of a particular sea must be greater than the fall below it." Owing to the extreme range of tides in the Bristol Channel, it seems very probable that the greater portion of the observed elevation of 9 inches may be due to the operation of this last-named law.

It would now seem that the illustrations above given are ample to establish the fact that Ferrel's law is supported by all actual differences in level of which we have knowledge.

Heretofore, these differing elevations have been held as doubtful, absurd, and unexplainable. They have been regarded as in opposition to mechanical principle. The officers of our own Coast Survey have rejected them utterly. They have held the Gulf and Atlantic to be at the same elevation, and have assumed the apparent elevation of the Gulf as due to some mysterious and systematic series of errors in levelling, by which, under some process still more mysterious, these distortions of fact have been made to appear always in one direction. Giving expression to their beliefs, they have also arbitrarily "adjusted" the elevations of some 4,000 bench-marks of the precise level lines of the United States, in an effort to eliminate these unexplainable differences. (See Report Coast and Geod. Survey, 1899, App. 8.)

The logic, the unquestioned value, the simplicity of Ferrel's law, however, now bring fact and theory once again into harmony. In the ocean currents, crowding against, or flowing from, the oceanic coast-lines, we find perfect explanation of all known cases of discrepancy in altitude.

We are now in position to advance one step farther in our examination as to the truth of Playfair's law, and may reason somewhat as follows:—

It will be admitted, I think without question, that the argument above presented has considerable weight, that there is mathematical support to Farrel's contention, and that when we assume the surface of the sea to be held at abnormal levels of elevation or depression, determined by the rate and direction of flow, there is logic and merit in our position.

Now, then, if these waters are so held at elevations of 3, 5, or 10 feet above or below the normal, depending on the direction and velocity, it is an incontestable deduction that if the slightest change in direction or velocity of these currents takes place, these waters should immediately alter their surface-level in corresponding degree, a rising sea-level at one location being necessarily accompanied by a falling sea-level at some not distant point.

We will now examine as to the probability or possibility of the occurrence of such suggested diversion and variation in currents. This question is almost a new one, but no difficulty should be encountered in entertaining the conception that such changes may have taken place in the past, notwithstanding the dearth of observation in this regard.

Pillsbury's study of the Gulf Stream has shown daily, monthly, and annual variations in flow, but these changes, owing to their short period, probably have little effect on the sea-level at distant points. His observations were not extended over a sufficient number of years to determine cycles of long period, but certain observations in this direction have been made by others, which are of such importance and have such direct bearing on the problem as to entitle them to mention.

In "Prehistoric Europe" Mr. James Geikie, from consideration of the variation in life-forms between Cape Cod and the Bay of Fundy, inferred that the Gulf Stream formerly carried into the north a "much greater body of heated water than now reaches such high latitude" (p. 503).

Dr. James Croll, from study of the fossils in the Carse clays of Scotland, held that when these clays were deposited the mean Winter temperature must have been 10° or 15° lower than at present, and that the Gulf Stream was then "considerably reduced." ("Climate and Cosmology," p. 115.) The recency of this change is affirmed by the fact that these clays contain many buried canoes and other relics of early man.

In Popular Sci. Monthly, vol. xx, p. 668, Mr. James Geikie is again quoted. He therein shows that the climate of North-Western Europe has been, and may yet again be, modified by changes in the flow of the Gulf Stream.

In the Smithsonian Report for 1869 M. Babinet discusses the deterioration in climate of Greenland and the Arctic regions generally during the last few centuries. His conclusion is that the only explanation of many observed facts connected with the movements of ice masses and variation of climate in those regions is found in a "diminution" of the Gulf Stream, and he "boldly affirms" that the current passing around North Cape is now decreasing and carrying less heat than formerly (p. 291).

In the article "Oscillations in the Sea-Level" (GEOLOGICAL MAGAZINE, April, May, and June, 1901) this writer also, like

Babinet, was compelled to invoke a recent diminution in the Gulf Stream to explain the progressive protrusion of the entire northern hemisphere above the level of the sea during the last three centuries.

Other changes in direction or velocity have been either actually observed or inferred from indirect evidence.

Humboldt informs us that a current near the Bahamas flowed to the south-east in 1787. It now flows to the north-west at a velocity of 26 miles a day.

Repeated statements have been made that at different times in the past the fish (cod or herring) industry, off the coasts of Ireland, Scotland, Denmark, and France, has been ruined or injured by the migrations made necessary by the diversions of ocean currents.

Dr. Bessel has shown that the currents of Davis Straits formerly ran in an opposite direction. Reclus has shown also that during the Tertiary period the Gulf Stream along the coast of Cuba had direction differing from that of the present.

It will be admitted that the citations above given in no case seem conclusive. They are mostly deductions made by those who have otherwise been unable to explain observed phenomena. Nevertheless, the established positions of many of those who have drawn these conclusions and the profound respect we entertain for their judgment should warrant us in accepting their decisions as most certainly probable.

We may adopt, therefore, as most reasonable, even if not yet firmly established, the following proposition:—Variation and diversion of ocean currents have certainly occurred in the past. It is probable that these changes may be going on to-day, and it is certain we must expect them in the future.

Now, then, it seems a mathematical certainty that if either variation or diversion in flow of ocean currents takes place the surface-levels on all coastlines must change in due proportion, and that these changes must necessarily be in opposite directions in not distant locations. It thus appears that Playfair's law, unchallenged for a century, has during all this time occupied a position to which it had no title. During the full lifetime of the science of geology we have been utilizing the apparent motions in the earth's crust herein considered as types, as living illustrations, of that uplifting of continents, that slow growth in mountain chains, required by our modern doctrines.

Playfair's theory has thus, by its absolute and unquestioned acceptance during this long period, put bar upon progress. No man had courage to question its correctness, therefore no man had occasion to seek other explanation. Now, however, the argument so long unassailable fails us; we find it weak, erroneous, impotent, and when we look back over our recent geologic pathway and see how much we have built upon this frail foundation, upon this uncertain inference of a plastic and mobile crust, one is tempted to ask how can such building be stable? How can such superstructure be more enduring than its supporting fabric?

VI.—A Tabular View of the Cretaceous Polyzoa of the Family Idmoniidæ.

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

In the Geological Magazine for 1906[1] a key of the published figures of the Cretaceous forms referable to the genus *Entalophora* was offered in the hope that by means of it the difficulties attendant on the determination of the species of this genus might be obviated.

A similar key was prepared for the difficult genus *Retecava*; but in its preparation it was found necessary to overhaul other genera of the family Idmoniidæ, a work which resulted in reducing all the genera of this family to a tabular form for the determination of the species. These tables are here given for the use of the collector in determining the forms and as a guide to the descriptions in the British Museum Catalogue.

I. The Genera comprising the Idmoniidæ.

The Idmoniidæ are defined as Cyclostomata Tubulata in which there is a 'reverse face' of the zoarium without apertures, and those on the 'obverse face' are arranged in rows symmetrically about the middle line.

Like other families of Cretaceous Polyzoa, the Idmoniidæ include encrusting and branching forms which pass in regular sequence from strap-shaped zoœcia through discoid to erect forms. There is no foliate genus like *Diastopora*[2] among the Diastoporidæ. The simplest genus, *Idmonea*, resembles forms of *Proboscina* such as *P. radiolitorum* and *P. anomala*; the former, as pointed out by Gregory,[3] being intermediate between *Proboscina* and *Idmonea*, thus suggesting the origin of the family.

The following is a tabular view of the genera included in the family:—

IDMONIIDÆ.

A. *Zoarium encrusting.*	
I. Zoarium strap-shaped (like *Proboscina*), or if discoid the zoœcia are arranged on strap-shaped ridges; apertures in alternate, pinnately-arranged rows.	
a. Apertures in single lateral series	*Idmonea.*
b. Apertures in double lateral series (except at extreme proximal end)	*Reptofascigera.*
(Only species, *R. alternata*, d'Orbigny, 1853: Pal. Franç. Bry. Crét., pl. 744, figs. 4–6.)	
II. Zoarium discoid (like *Berenicea*); zoœcia in radially-arranged rows	*Phalangella.*
(Only Cretaceous species, *Berenicea radians*, Novak, 1877, Bry. Böhm. Kr.: Denk. Ak. Wiss. Wien., vol. xxxvii, pt. 2, pl. iv, figs. 15–18.)	
B. *Zoarium erect, of hollow branches*	*Semiclausa.*

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[1] W. D. Lang, "A Key to the Published Figures of the Cretaceous Forms of *Entalophora*": Geol. Mag., 1906, p. 462.

[2] Cf. a similar case in the Eleidæ: see Lang, Geol. Mag., 1906, p. 60.

[3] J. W. Gregory: Brit. Mus. Cat. of Cretaceous Bryozoa, vol. i (1899), p. 150.

C. *Zoarium erect, of solid branches.*

I. No unpaired median nor multiple median series of apertures.

a. Apertures in double lateral series ... ... *Bitubigera.* (Only Cretaceous species, *B. compressa*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. iii, fig. 1.)

b. Apertures in single lateral series.

1. Apertures circular or tear-shaped. In the former case longitudinal grooves, slots, or circular depressions are present on the zoarium; in the latter case the reverse face is very narrow.

α. Zoarium very compressed in a plane at right angles to that of the obverse and reverse faces; reverse face well developed ... ... *Bicrisina.*

β. Zoarium not very compressed; reverse face very narrow *Sulcocava.*

2. Apertures circular (tear-shaped in two species of *Retecava*, but in both the reverse face is well developed). If longitudinal grooves or depressions are present on the zoarium, it is never very compressed in a plane at right angles to that of the obverse and reverse faces (as in *Bicrisina*), nor is the reverse face reduced (as in *Sulcocava*).

α. Branches very compressed in a plane at right angles to that of the obverse and reverse faces; or if not so compressed the reverse face is very narrow ... ... *Reticrisina.*

β. Branches cylindrical or moderately compressed; reverse face well developed.

a. An 'axial rod' more or less developed on the reverse side ... ... *Retecava.*

b. No 'axial rod' ... ... *Crisina.*

II. An unpaired median series of apertures; lateral series simple *Tervia.*

III. A multiple median series of apertures; lateral series multiple *Pergensella.*
(Only species—
Idmonea geniculata, von Hagenow, 1851: Bry. Maastr. Kr., pl. iii, fig. 5.
Retepora clathrata, *pars*, Goldfuss, 1827: Petrefact. Germ., vol. i, pl. ix, figs. 12*e–f*.
Pergensella geniculata, Gregory, 1899: Brit. Mus. Cat. Cret. Polyzoa, p. 210, figs. 19–20.)

Until the forms consisting of solid branches are reached, the development of the family appears fairly simple. The genus *Semiclausa*, consisting of hollow tubes, probably arose, like the hollow Diastoporas (such as *D. ramosissima*, d'Orbigny), by the folding of an erect unilamilar zoarium. Such a form has not yet been found; but it only needs the erection of the distal end of an *Idmonea* to produce it. Until the proximal ends of d'Orbigny's two species of *Semiclausa* are found nothing definite can be known of their origin. For it is conceivable that they may be encrusting forms which have grown on some perishable cylindrical base, such as a stem of seaweed, the decomposition of which has left the encrusting Polyzoan in the form of a hollow tube.

Gregory has produced evidence of the origin of *Crisina* in the shape of a discoid base of this genus resembling *Phalangella*.[1] This is exactly comparable with the specimen he figures of an *Entalophora* arising directly from a *Berenicea*-like base.[2]

The origin of *Reptofascigera* from *Idmonea* is clearly shown in d'Orbigny's figure of the only species of that genus. At the extreme proximal end of the zoarium the apertures are in single lateral series, i.e. proximally the form is an *Idmonea*.

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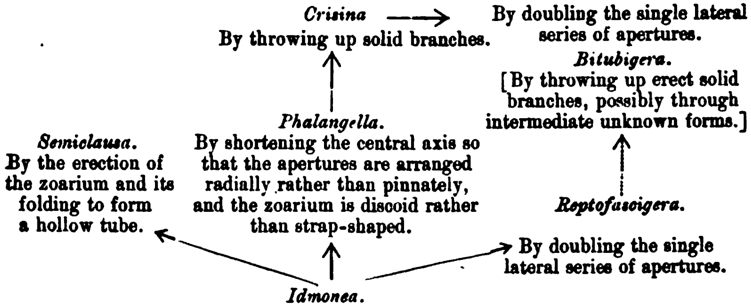
[1] J. W. Gregory: Brit. Mus. Cat. Cret. Bryozoa, vol. i (1899), p. 159, fig. 11.

[2] J. W. Gregory: loc. cit., p. 217, fig. 26.

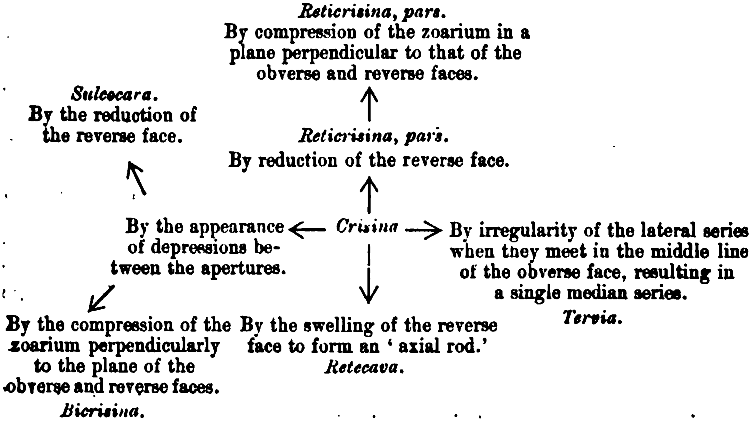
Without the knowledge of the proximal end of ***Bitubigera*** it is uncertain whether this form arose directly from ***Crisina***, as ***Reptofascigera*** from *Idmonea*, by doubling the single lateral series of apertures, or through intermediate unknown forms from ***Reptofascigera***.

The following diagram summarizes these suggestions as to the origin of the simpler genera:—


Crisina
By throwing up solid branches.
By doubling the single lateral series of apertures.
Bitubigera.
[By throwing up erect solid branches, possibly through intermediate unknown forms.]
Phalangella.
Semiclausa.
By the erection of the zoarium and its folding to form a hollow tube.
By shortening the central axis so that the apertures are arranged radially rather than pinnately, and the zoarium is discoid rather than strap-shaped.
Reptofascigera.
By doubling the single lateral series of apertures.
Idmonea.

The forms distributed among the remaining genera are not easy to group. ***Tervia***, ***Reticrisina***, and ***Crisina*** (restricted) are considered by Gregory as subgenera of *Crisina*; and there is no doubt of their close relationship. But the species of *Crisina* and of ***Retecava*** are very hard to separate, and the latter genus resembles ***Sulcocava*** and ***Bicrisina***. ***Pergensella*** is very isolated, and there is no evidence of its origin.

The following scheme suggests the main lines of development, but it does not represent all the facts, for species of intermediate nature occur between various genera, showing that probably the genera are artificial. Hence the clumsy definitions in the table of genera given above.


Reticrisina, pars.
By compression of the zoarium in a plane perpendicular to that of the obverse and reverse faces.
Sulcocava.
By the reduction of the reverse face.
Reticrisina, pars.
By reduction of the reverse face.
By the appearance of depressions between the apertures.
Crisina
By irregularity of the lateral series when they meet in the middle line of the obverse face, resulting in a single median series.
Tervia.
By the compression of the zoarium perpendicularly to the plane of the obverse and reverse faces.
Bicrisina.
By the swelling of the reverse face to form an 'axial rod.'
Retecava.

II. The Subdivisions of the Genera.

In the following tables for the subdivision of the genera references are given only to those forms which are figured; for it is often almost impossible to be sure of the species intended by descriptions unaccompanied by figures, in the case of these obscure forms. But as these tables are not intended to show natural relationships, but only as keys to help the collector to determine the forms described in the British Museum Catalogue, the synonymy of the species is assumed to be that given in the Catalogue. The remarks prefacing the table of the genus *Entalophora* in the former paper are applicable here. The genera *Crisina* and *Retecava* are taken together, owing to the difficulty of separating them in practice. Theoretically a solid rod-like thickening occupies the reverse side of the zoarium in *Retecava*; while that of *Crisina* is not wider than the obverse side. But forms of *Retecava* occur, such as *R. cypris* (d'Orbigny) and *R. grandis* (d'Orbigny), in which the 'axial rod' is reduced or hardly distinguishable; while in *Crisina ligeriensis*, d'Orbigny, the reverse side is decidedly rod-like. The morphological significance of the 'axial rod' stands or falls with that of the 'canaux de renforcement' of Pergens,[1] structures which can only be identified in longitudinal sections.

Idmonea.

I. Zoarium of one or two (connected only at their proximal ends) strap-shaped zoœcium-bearing ridges, each of which may have its own 'selvage.'
  A. Zoarium long and narrow (about six times as long as broad), with or without a 'selvage.'
    a. Zoœcia emergent.
      Reptotubigera cristata, Meunier & Pergens, 1885, Nouv. Bry. Crét. Sup.: Mém. Soc. Roy. Malac. Belge, pl. ii, fig. 7.
      Idmonea cristata, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., vol. i, pl. viii, figs. 4*a*, 4*b*.
    b. Zoœcia immersed.
      Idmonea alipes, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., vol. i, pl. viii, figs. 2. 3.
  B. Zoarium short (about three times as long as broad), rapidly becoming broader distally, without a 'selvage.'
      Idmonea virgula, d'Orbigny, 1851: Bry. Crét., pl. 631, figs. 15–17.
      Reptotubigera simplex, de Loriol, 1853: Invert. Mt. Salève, pl. xvi, fig. 3.
II. Zoarium of many zoœcium-bearing ridges, rising from a common 'selvage.'
  A. Ridges short (seldom more than three times, generally about twice as long as broad) and straight.
    a. Two to three zoœcia in a lateral series.
      Reptoclausa neocomiensis, de Loriol, 1863: Invert. Mt. Salève, pl. xvii, fig. 7.
    b. Three or four zoœcia in a lateral series.
      Reptoclausa obliqua, d'Orbigny, 1853: Bry. Crét., pl. 765, figs. 3, 4.
    c. Five or six zoœcia in a lateral series.
      Reptoclausa neocomiensis, d'Orbigny, 1853: Bry. Crét., pl. 765, figs. 1, 2.

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[1] Pergens, 1890, "Revision des Bryozoaires du Crétacé," p. 311; and J. W. Gregory, 1899, Brit. Mus. Cat. Cret. Bry., vol. i, p. 149.

B. Ridges long (six or more times as long as broad) and often wavy.
  a. Four to six zoœcia in the breadth of a ridge.
    Lopholepis Hagenowi, Sharpe, 1854: Quart. Journ. Geol. Soc., pl. v, fig. 7.
    Idmonea Hagenowi, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., pl. viii, figs. 1*a*, *b*.
  b. Five to seven zoœcia in the breadth of a ridge.
    Reptoclausa meandrina, de Loriol, 1868, Val. Arz.: Pal. Suisse, ser. IV, pt. 2, pl. vi, fig. 1.

SEMICLAUSA.

A. Zoarium a flattened tube; zoœcium-bearing ridges arranged pinnately.
    Semiclausa alternata, d'Orbigny, 1853: Bry. Crét., pl. 764, figs. 6–10.
B. Zoarium a tube, triangular in cross-section; zoœcium-bearing ridges arranged in longitudinal rows.
    Semiclausa angulosa, d'Orbigny, 1853: Bry. Crét., pl. 764, figs. 11–13.

BICRISINA.

A. Depressions between the apertures circular; apertures about twelve to fifteen in a series; reverse face occupies about half the zoarium.
    Bicrisina Gaudryi, Pergens, 1890: Revision, pl. xiii, fig. 2.
B. Depressions between the apertures tear-shaped; apertures about eight in a series; reverse face not so extensive as in *B. Gaudryi*.
    Reticulipora cultrata, d'Orbigny: 1851, Bry. Crét., pl. 611, figs. 6–10; 1853, Bry. Crét., pl. 768, figs. 11–15.

SULCOCAVA.

A. Apertures circular.
  I. Zoarium strongly fluted.
    a. Distance between apertures of the same series about one diameter of an aperture. Reverse face almost obliterated.
      Sulcocava sulcata, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 1–3.
    b. Distance between apertures of the same series less than one diameter of an aperture. Reverse face fairly developed.
      Sulcocara costulata, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pt. 1, pl. ii, fig. 1.
  II. Zoarium with slot-shaped depressions between the apertures.
    Sulcocava cristata, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, p. 212, fig. 21.
    Sulcocava gracilis, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, p. 214, fig. 23.
  III. Zoarium with faint longitudinal depressions between the apertures.
    Laterocava gracilis, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 17–20.
B. Apertures tear-shaped.
  I. Apertures about eight in a series.
    Sulcocava cristata, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 4–8.
    Sulcocava lacryma, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 9–12.
  II. Apertures about twelve in a series.
    Laterocava rustica, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 13–16.

RETICRISINA.

A. Branches of zoarium form a regular, dense network, the meshes of which are hexagons or squares.
    Reticulipora ligeriensis, d'Orbigny, 1851: Bry. Crét., pl. 609, figs. 1-6.
    Reticulipora girondina, d'Orbigny, 1851: Bry. Crét., pl. 609, figs. 7-12.

B. Branches of zoarium, if anastomosing, form only a loose network, the meshes of which are flame-shaped.

- **I. Zoarium very compressed in a plane at right angles to that of the obverse and reverse faces, being about five or six times as high as wide.**
  - **a. Apertures about seven in a series.**
    - *Reticulipora papyracea*, d'Orbigny: 1851, Bry. Crét., pl. 611, figs. 1–5; 1853, Bry. Crét., pl. 768, figs. 3–10.
    - *Reticulipora complanata*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. iii, fig. 10.
    - *Reticrisina papyracea*, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, pl. ix, figs. 1–3.
  - **b. Apertures twelve to twenty in a series.**
    - *Reticulipora obliqua*, d'Orbigny: 1851, Bry. Crét., pl. 610, figs. 1–5; 1853, Bry. Crét., pl. 768, figs. 1, 2.
    - *Reticrisina obliqua*, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, p. 177, fig. 13; pl. viii, figs. 8, 9.
- **II. Zoarium compressed in a plane at right angles to that of the obverse and reverse faces, but only three or four times as high as wide. Apertures about nine in a series.**
  - *Cricopora gradata*, Leymerie, 1851, Type. Pyren. par. à Craie: Mém. Soc. géol. France, ser. II, vol. iv, pl. ix, fig. 7.
- **III. Zoarium only slightly, if at all, compressed in a plane at right angles to that of the obverse and reverse faces.**
  - *Retepora disticha*, *pars*, Goldfuss, 1827: Petref. Germ., vol. i, pl. ix, figs. 15*c*, *d*.
  - *Idmonea disticha*, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 8.
  - *Idmonea maculata*, *pars*, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, figs. 3*e*–*g*.
  - *Tubigera distiqua*, d'Orbigny, 1853: Bry. Crét., pl. 746, figs. 2–6.
  - *Ceriopora subcompressa*, von Hagenow, 1845: in Geinitz, Grundr. Verst., pl. xxiii*b*, fig. 15.
  - *Idmonea subcompressa*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. ii, fig. 7.
  - *Stichopora regularis*, d'Orbigny, 1851: Bry. Crét., pl. 613, figs. 11–15.
  - *Tubigera antiqua*, d'Orbigny, 1853: Bry. Crét., pl. 746, fig. 1.
  - *Tubigera distans*, d'Orbigny, 1853: Bry. Crét., pl. 746, figs. 7–11.
  - *Reticrisina disticha*, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, p. 184, fig. 14.

Tervia.

A. Zoœcia one or two in a lateral series.

- **1. Distance between the series of apertures two to three times the diameter of an aperture; zoarium cylindrical; zoœcia immersed; distance between apertures of the same series one diameter of an aperture.**
  - *Crisina subgracilis*, d'Orbigny, 1851: Bry. Crét., pl. 614, figs. 6–10.
  - *Idmonea subgracilis*, Pergens, 1890: Revision, pl. xii, fig. 2.
- **2. Distance between the series of apertures four times the diameter of an aperture; zoarium flattened in the plane of the obverse and reverse faces; zoœcia immersed; distance between apertures of the same series one diameter of an aperture.**
  - *Filisparsa pulchella*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. iii, fig. 7.

T. subgracilis.

- **3. Distance between the series of apertures four to seven times the diameter of an aperture.**
  - **a. Apertures one only in a series; zoarium flattened in the plane of the obverse and reverse faces; zoœcia immersed or boundaries slightly shown.**

Filisparsa simplex, von Reuss, 1874, Bry. ob. Plän.: Palæontogr., vol. xx, pt. 2, pl. xxv, fig. 1.

b. Apertures one to two in a series; zoarium cylindrical; zoœcia immersed, or boundaries shown, or slightly emergent; apertures of the same series distant half a diameter of an aperture.

Idmonea Muelleri, Beissel, 1865, Bry. Aach. kr.: Nat. Verh. Holl. Maat. Wet., ser. II, vol. xxii, p. 77, pl. ix, figs. 105–106.

Filisparsa Muelleri, Beissel, 1865: op. cit., pl. x, figs. 129–131.

T. Muelleri.

B. Zoœcia alternately two and three in a lateral series; zoarium flat on the reverse side, triangular in section; zoœcia immersed, with boundaries shown; zoœcia of same series distant two to three diameters of an aperture, those of different series four to five diameters of an aperture.

Idmonea decurrens, Pocta, 1892, Mech. koryc. Hory.: Ceska. Ak. Fr. Jos. Praze, sect. 2, pl. ii, figs. 3–6.

T. decurrens.

C. Zoœcia three to four in a lateral series.

1. Zoarium clavate; zoœcia immersed; zoœcia of same series distant one to two diameters, and those of different series four to five diameters of aperture.

Clavitubigera depressa, d'Orbigny, 1853: Bry. Crét., pl. 747, figs. 1–5.

T. subgracilis.

2. Zoarium compressed in a plane at right angles to that of the obverse and reverse faces; zoœcia immersed, but their boundaries are well marked; zoœcia of the same series distant one to one and a half times, those of different series three to four times, the diameter of an aperture.

Tervia Gamblei, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, pl. ix, fig. 9.

T. Gamblei.

3. Zoarium cylindrical or flattened in a plane parallel to that of the obverse and reverse faces.

a. Zoarium with 'dorsal processes' without apertures projecting from the reverse face; zoarium cylindrical, but reverse face is flat; zoœcia immersed, with boundaries very slightly shown; zoœcia of the same series distant one-half, those of different series three to four times, the diameter of an aperture.

Tervia gibbera, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, p. 174, fig. 12.

T. gibbera.

b. Zoarium without 'dorsal processes.'

α. Distance between the different series of apertures one and a half to two and a half times the diameter of an aperture; zoarium flattened in a plane parallel to obverse and reverse faces; reverse face flat or slightly concave; zoœcia immersed, but boundaries may be prominent. Apertures of same series distant one-quarter to one diameter of an aperture.

Idmonea dorsata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 10.

Idmonea dorsata, d'Orbigny, 1853: Bry. Crét., pl. 748, figs. 16–19.

Idmonea dorsata,[1] Pergens, 1890: Revision, pl. xii, fig. 5.

β. Distance between the different series of apertures three diameters of an aperture.

1. Distance between apertures of the same series one and a half to two diameters of an aperture; zoarium flattened in a plane parallel to that of the obverse and reverse faces; zoœcia immersed, boundaries not shown or hardly shown.

Idmonea dorsata, var. *Faxeensis*, Pergens & Meunier, 1887, Bry. gar. Faxe: Ann. Soc. Roy. Malac. Belge, vol. xxi, pl. xi, fig. 1.

2. Distance between apertures of the same series one-half the diameter of an aperture; zoarium cylindrical, zoœcia immersed.

Retepora disticha, pars, Goldfuss, 1827: Petref. Germ., vol. i, pl. ix, figs. 15*g*, *h*.

T. dorsata.

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[1] Most of the characters of *I. dorsata* are not shown on Pergens' figure. There are remains of what might have been 'dorsal processes.'

CRISINA–RETECAVA.

- A. Zoarium cylindrical or subtriangular or subquadrangular in cross-section, or flattened in a plane at right angles to the obverse and reverse faces.
  - I. Lateral series quite irregular.
    - *a.* Zoarium with a strong, blunt median keel 1
    - *b.* Zoarium with a strong, thin median keel 2
  - II. A few scattered apertures between the somewhat wavy lateral series ... 3
  - III. Lateral series regular.
    - *a.* Apertures elongate in a proximal-distal direction.
      - 1. Apertures about four in a series 4
      - 2. Apertures ten or more in a series 5
    - *b.* Apertures circular or nearly so.
      - 1. Reverse face convex.
        - *α.* Apertures one or occasionally two in a series 6
        - *β.* Apertures 2–6 in a series.
          - *a.* No decided keel on the obverse face, nor much compressed.
            - 1. Apertures decreasing in size from the middle of the obverse face outwards 7
            - 2. Apertures all of one size.
              - *α.* Zoœcia immersed and boundaries to zoœcia not strongly marked.
                - *a.* Series of apertures do not reach the middle line of obverse face.
                  - 1. Branches connected by cross-bars which bear no apertures 8
                  - 2. Branches with no cross-bars.
                    - *α.* Distance between series of apertures 5–8 or more times the diameter of aperture.
                      - *a.* Apertures two in a series, branches take a zigzag course 9
                      - *b.* Apertures 3–4 in a series; those of same series distant about half diameter of aperture ... 10
                      - *c.* Apertures 4–5 in a series; those of same series distant three-quarters diameter of aperture ... 11
                    - *β.* Distance between series of apertures 2–3 diameters of apertures 12
                - *b.* Series of apertures meet the middle line.
                  - 1. Apertures of same series distant less than one diameter of aperture.
                    - *α.* Apertures of different series distant 1–3 diameters of aperture 13
                    - *β.* Apertures of different series distant about three diameters of aperture 14
                    - *γ.* Apertures of different series distant 4–8 diameters of aperture 15
                  - 2. Apertures of same series distant one diameter of aperture 16
              - *β.* Zoœcia immersed, but boundaries of zoœcia are strongly marked.
                - 1. Zoœcia two only in a series 17
                - 2. Zoœcia three (occasionally two) in a series 18
                - 3. Zoœcia four in a series 19
                - 4. Zoœcia six in a series (series of apertures do not reach the middle line) 20
              - *γ.* Zoœcia emergent 21
          - *b.* A decided keel on obverse face or decidedly compressed.
            - 1. Apertures of same series distant one or more than one diameter of aperture.
              - *α.* Reverse face marked with linear depressions 22
              - *β.* Reverse face marked with reticular depressions 23
            - 2. Apertures of same series distant less than one diameter of aperture.

α. Apertures of different series distant 3–6 diameters of aperture 24
β. Apertures of different series distant 1½–3 diameters of aperture 25
γ. Apertures 6–15 in a series.
a. Series of apertures distant 3–4 diameters of aperture 26
b. Series of apertures distant 2–3 diameters of aperture.
1. Apertures of the same series distant ½–2 diameters of aperture 27
2. Apertures of the same series distant ½–1 diameter of aperture 28
2. Reverse face flat or concave, apertures 3–8 in a series 29
B. Zoarium flattened in a plane parallel to the obverse and reverse faces.
I. Reverse face flat or convex, series of apertures close together, apertures 5–8 in a series 30
II. Reverse face concave, series of apertures far apart, apertures 3–5 in a series 31
C. Zoarium clavate.
I. Reverse face convex, apertures 3–7 in a series 32
II. Reverse face concave, apertures 6 in a series 33

1.	*Reticulipora ramosa*, d'Orbigny, 1851: Bry. Crét., pl. 610, figs. 7–11...	*R. clathrata.*
2.	*Reticulipora sagena*, Gabb & Horn, 1860, New Amer. Foss.: Journ. Acad. Nat. Sci. Phil., ser. II, vol. iv, pl. lxix, figs. 30–32	*R. sagena.*
	Idmonea dichotoma, Gabb & Horn, 1862, Mon. Foss. Poly. N. Amer.: Journ. Acad. Nat. Sci. Phil., ser. II, vol. v, pl. xxi, fig. 64	*R. dichotoma.*
3.	*Retecava areolata*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. iii, fig. 9	*R. areolata.*
4.	*Idmonea lineata*, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 13	*R. pseudodisticha.*
5.	*Idmonea gibbosa*, von Hagenow, 1851: loc. cit., pl. ii, fig. 14	*R. gibbosa.*
6.	*Crisina unipora*, d'Orbigny, 1851: loc. cit., pl. 613, figs. 1–5	*C. unipora.*
	Crisina elegans, d'Orbigny, 1851: loc. cit., pl. 613, figs. 6–10...	,,
	Idmonea francorum, Pergens, 1890: Revision, pl. xiii fig. 1.	,,
	Retepora gracilis, von Hagenow, 1846: in Geinitz, Grundr. Verst., pl. xxiii *b*, fig. 4	,,
	Crisina unipora, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., vol. i, pl. viii, figs. 5 and 6	,,
	Idmonea unipora, Beissel, 1865, Bry. Aach. kr.: Nat. Verh. Holl. Maatsch. Wet., ser. II, vol. xxii, pl. viii, figs. 97–99	*R. cretacea.*
7.	*Bicrisina Abbotti*, Gabb & Horn, 1862, Foss. Poly. N. Amer.: Journ. Acad. Nat. Sci. Phil., ser. II, vol. v, pl. xxi, fig. 65	*R. Abbotti.*
	Idmonea pseudodisticha, Marsson, 1887: loc. cit., pl. ii, fig. 8*b*	?
8.	*Retepora cancellata*, Goldfuss, 1829: Petref. Germ., vol. i, pl. xxxvi, fig. 17	*R. cancellata.*
	Retepora cancellata, von Hagenow, 1846: in Geinitz, Grundr. Verst., pl. xxiii *b*, fig. 2	,,
	Idmonea cancellata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 7	,,
	Idmonea cancellata, d'Orbigny, 1853: loc. cit., pl. 748, figs. 20–23	,,
9.	*Retepora gracilis*, von Hagenow, 1846: in Geinitz, Grundr. Verst., pl. xxiii *b*, fig. 4...	*C. unipora.*
10.	*Crisina subgradata*, d'Orbigny, 1851: loc. cit., pl. 612, figs. 6–10...	*R. subgradata.*
	Idmonea pseudodisticha, Marsson, 1887: loc. cit., pl. ii, fig. 8*a*	?
	Idmonea laticosta, Marsson, 1887: loc. cit., pl. ii, fig. 11	*R. pseudodisticha.*

11.	***Idmonea commutata***, Marsson, 1887: loc. cit., pl. ii, fig. 10	***R. pseudodisticha.***
12.	***Idmonea cretacea***, Milne Edwards, 1838, Mém. Cris.: Amer. Sci. Nat. Zool., ser. II, vol. ix, pl. xii, fig. 5. Lonsdale, 1850: in Dixon, Geol. Sussex, pl. xviii*a*, figs. 5, 5*a–h* …	***R. cretacea.***
	Retecava cretacea, Gregory, 1899: loc. cit., pl. ix, fig. 8.	,,
	Idmonea Dixoniana, Mantell, 1844: Med. Creat., vol. i, p. 284, figs. 6, 12 …	,,
	Crisidmonea macropora, Marsson, 1887: loc. cit., pl. ii, fig. 13 …	,,
	Retepora lichenoides, Goldfuss, 1827: loc. cit., pl. ix, fig. 13	***R. lichenoides.***
	Idmonea lichenoides, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 6 …	,,
	Cœlophyma granulatum, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 17 …	,,
	Idmonea carantina, d'Orbigny, 1853: loc. cit., pl. 748, figs. 1–5 …	***R. carantina.***
13.	***Idmonea disticha***, Michelin, 1845: Icon. Zooph., pl. lii, fig. 18 …	***C. cenomana.***
	Crisina cenomana, d'Orbigny, 1851: loc. cit., pl. 614, figs. 1–5 …	,,
	Idmonea cenomana, Pergens, 1890: loc. cit., pl. xii, fig. 3.	,,
	Retepora disticha, Goldfuss, 1827: loc. cit., pl. ix, figs. 15*e*, *f* …	***R. pseudodisticha.***
	Idmonea maculata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, figs. 3*a–d* …	,,
	Heterocrisina Abbotti, Gabb & Horn, 1860: Journ. Acad. Nat. Sci. Phil., ser. II, vol. iv, pl. lxix, figs. 45–47 …	***R. Abbotti.***
14.	***Idmonea striatola***, Marsson, 1887: loc. cit., pl. ii, fig. 9 ..	***R. carinata.***
15.	***Idmonea disticha***, Michelin, 1845: loc. cit., pl. lii, fig. 18	***C. cenomana.***
	Idmonea insignis, Marsson, 1887: loc. cit., pl. ii. fig. 12…	***R. insignis.***
16.	***Idmonea cypris***, d'Orbigny, 1853: loc. cit., pl. 749, figs. 7–10 …	***R. cypris.***
17.	***Idmonea francorum***, Pergens, 1890: loc. cit., pl. xiii, fig. 1	***C. unipora.***
18.	***Idmonea cretacea***, M. Edwards, 1838: loc. cit., pl. xii, fig. 5	***R. cretacea.***
	Idmonea communis, d'Orbigny, 1853: loc. cit., pl. 750, figs. 6–10 …	,,
	Idmonea prima, Pocta, 1892, Mech. Koryc. Hory.: Cesk. Akad. Cis. Fr. Jos., sect. 2, pl. ii, figs. 7–11… …	***C. cenomana.***
19.	***Crisina normaniana***, d'Orbigny, 1851: loc. cit., pl. 612, figs. 1–5 …	***C. cenomana.***
20.	***Idmonea grandis***, d'Orbigny, 1853: loc. cit., pl. 749, figs. 16–19 …	***R. grandis.***
21.	***Idmonea pseudodisticha***, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 9. D'Orbigny, 1853: loc. cit., pl. 749, figs. 1–6 …	***R. pseudodisticha.***
	Idmonea irregularis, Beissel, 1865: loc. cit., pl. viii, figs. 102–104 …	,,
	Idmonea unipora, Beissel, 1865: loc. cit., pl. viii, figs. 98, 100 …	***R. cretacea.***
	Crisina cenomana, var. ***triangularis***, d'Orbigny: Gregory, 1899, loc. cit., pl. viii, fig. 7 …	***C. cenomana***, var. ***triangularis.***
22.	***Idmonea lichenoides***, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 6 …	***R. lichenoides.***
23.	***Idmonea geometrica***, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 11 …	***R. geometrica.***
24.	***Crisina triangularis***, d'Orbigny, 1851: loc. cit., pl. 612, figs. 11–15 …	***C. cenomana.***
	Crisina ligeriensis, d'Orbigny, 1851: loc. cit., pl. 614, figs. 11–15 …	,,
25.	***Retecava carinata***, Gregory, 1899: loc. cit., p. 198, fig. 17	***R. carinata.***
	Idmonea sulcata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 12 …	,,

	Idmonea cytherea, d'Orbigny, 1853: loc. cit., pl. 750, figs. 11–15	*R. carinata.*
26.	*Crisina ramosa*, d'Orbigny, 1851: loc. cit., pl. 611, figs. 11–15	*R. ramosa.*
	Idmonea macilenta, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 4	,,
	Idmonea divaricata, Ubaghs, 1865, Bry. Schicht. Maastr.: Verh. naturh. Ver. Preuss. Rheinl., vol. xxii, pl. iii, fig. 8	,,
27.	*Retepora clathrata*, Goldfuss, 1827: loc. cit., pl. x, figs. 12*c*, *d*	*R. clathrata.*
	Idmonea clathrata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 2	,,
	Retecava clathrata, d'Orbigny, 1853: pl. 790, figs. 5–9.	,,
	Idmonea verriculata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 5	,,
28.	*Idmonea carinata*, Roemer, 1840: loc. cit., pl. v, fig. 20.	*R. carinata.*
29.	*Idmonea filiformis*, d'Orbigny, 1853: loc. cit., pl. 750, figs. 1–5	*R. pseudodisticha.*
	Idmonea angulosa, d'Orbigny, 1853: loc. cit., pl. 748, figs. 11–15	*C. angulosa.*
	Idmonea marginata, d'Orbigny, 1853: loc. cit., pl. 749, figs. 20–23	*C. marginata.*
	Idmonea lata, d'Orbigny, 1853: loc. cit., pl. 748, figs. 6–10.	,,
	Idmonea excavata, d'Orbigny, 1853: loc. cit., pl. 749, figs. 11–15	,,
	Idmonea calypso, d'Orbigny, 1853: loc. cit., pl. 747, figs. 11–14	*C. cenomana.*
30.	*Idmonea plana*, Pocta, 1892: loc. cit., pl. ii, figs. 1, 2	*C. plana.*
31.	*Clavitubigera navicularis*, Beissel, 1865: loc. cit., pl. viii, figs. 94–96	*C. navicularis.*
32.	*Clavitubigera convexa*, d'Orbigny, 1853: loc. cit., pl. 746, figs. 12–15	*C. convexa.*
	Clavitubigera angustata, d'Orbigny, 1853: loc. cit., pl. 746, figs. 16–20	,,
33.	*Clavitubigera excavata*, d'Orbigny, 1853: loc. cit., pl. 747, figs. 6–9	*C. Fischeri.*
	Idmonea Fischeri, Pergens, 1890: loc. cit., pl. xii, fig. 4.	,,

VII.—The Comparative Fertility of the Soil above certain Geological Formations.

By James Love, F.G.S., F.R.A.S.

While travelling over the country it may be noticed that the land is not uniformly fertile. In some places there is greater luxuriance and greater variety of plant life than in others. The question which such observations call forth is what is the cause of these differences? An attempt has been made to give some sort of answer to this question in the following manner:—A limited area has been selected which is traversed by a number of geological formations, and the plants growing on that area have been catalogued. The area selected in the present instance is the county of Surrey, that being the county which is best known to me. Surrey is too small a county to have any difference of climate. The differences of altitude would probably bring about some variety in the flora, but the differences of latitude could scarcely have any appreciable effect. The county is, however, large enough to include a dozen different rock formations within its boundary, and it seems fair to presume that these may have a considerable influence in determining the distribution and variation of its flora. Of the 1,310 species of plants figured and described in Bentham's British Flora, about 1,000, or approximately three-quarters of the whole flora, have been found growing in Surrey; these are arranged with the rocks over which they grow in the following order of diminishing numbers:—

ROCK FORMATIONS.	SPECIES OF PLANTS.
Lower Greensand	711
Gravel	655
Chalk	523
Bagshot Beds	513
London Clay	496
Weald Clay	364
Gault and Upper Greensand	356
Alluvium	302
Hastings Beds	281
Woolwich and Reading Beds	214
Thanet Beds	204

Perhaps it might be supposed that these numbers of plants would accord with the extent of area of the rocks over which they are growing. To determine this point the areas of the rocks which form the surface of the land within the county boundary of Surrey have been measured, and are arranged in the following order of diminishing areas, the figures giving the number of square miles of each formation:—

ROCK FORMATIONS.	AREAS.
Weald Clay	165·4 sq. miles
Lower Greensand	149·6 ,,
Chalk	119·32 ,,
London Clay	113·27 ,,
Bagshot Beds	93·84 ,,
Gravel	63·84 ,,
Woolwich and Reading	23·84 ,,
Alluvium	22·1 ,,
Gault and Upper Greensand	15·7 ,,
Hastings Beds	11·4 ,,
Thanet Beds	4·33 ,,

Dividing the number of species of plants growing over each formation by the number of square miles of the exposed surface of that formation will give the number of species of plants per square mile of rock surface. This may be called the density of species. They are the following, again in the order of diminishing numbers:—

ROCK FORMATIONS.	SPECIES PER SQUARE MILE.
Thanet Beds	47·1
Hastings Beds	24·65
Gault and Upper Greensand	22·65
Alluvium	13·66
Gravel	10·26
Woolwich and Reading	9·0
Bagshot Beds	5·47
Lower Greensand	4·75
Chalk	4·39
London Clay	4·38
Weald Clay	2·21

The result may be summarised in the following table, in which the rock formations are arranged in the descending order of stratification:—

Rock Formations.	Number of species.	Number of sq. miles.	Number of species per sq. mile.
Alluvium	302	22·1	13·66
Gravel	655	63·84	10·26
Bagshot Beds	513	93·84	5·47
London Clay	496	113·27	4·38
Woolwich and Reading	214	23·84	9·0
Thanet Beds	204	4·33	47·1
Chalk	523	119·32	4·39
Upper Greensand and Gault	356	15·7	22·65
Lower Greensand	711	149·6	4·75
Weald Clay	364	165·4	2·21
Hastings Beds	281	11·4	24·65

REVIEWS.

I.—The Progress of Palæontology.

Palæontographical Society, Vol. LX. Issued for 1906 (December, 1906). Printed for the Society (agents, Messrs. Dulau & Co.). 4to. Containing:—

1. The Pleistocene Bears, Vol. II, Part 2; by Prof. S. H. Reynolds, M.A., F.G.S. pp. 1–35, pls. i–viii.
2. The Fishes of the Old Red Sandstone, Part II, No. 3: the Asterolepidæ; by Dr. R. H. Traquair, F.R.S. pp. 119–130, pls. xxvii–xxxi.
3. The Cretaceous Lamellibranchia of England, Vol. II, Part 3; by Henry Woods, M.A. pp. 97–132, pls. xii–xix.
4. The Lower Palæozoic Trilobites of the Girvan District, Ayrshire, Part III; by F. R. Cowper Reed, M.A., F.G.S. pp. 97–186, with title-page, index, and pls. xiv–xx.
5. British Cambrian Trilobites, Part I; by Philip Lake, M.A., F.G.S. pp. 1–28, pls. i–ii.
6. British Graptolites, Part V; by Gertrude L. Elles, Sc.D., and E. M. R. Wood (Mrs. Shakespear), D.Sc. Edited by Charles Lapworth, LL.D., F.R.S., etc. pp. lxxiii–xcvi, 181–216, pls. xxvi–xxvii.

THIS Society has just issued its sixtieth annual volume for December, 1906, which still maintains its high reputation for the excellence of its monographs and the accuracy and beauty of its illustrations.

The fifty-ninth volume appeared in November, 1905, and contained the fossil Cretaceous Echinodermata, by W. K. Spencer; the Cretaceous Lamellibranchia, by H. Woods; the Carboniferous Lamellibranchia, by Dr. W. Hind; the Inferior Oolite Ammonites, by S. S. Buckman; and the Cornbrash Fauna, Part I, by the Rev. J. F. Blake. With regard to this last work, it is with deep regret we refer to the sad loss the Society has sustained by the death of the Rev. J. F. Blake, whose monograph on the Fauna of the Cornbrash had only been commenced in 1905 (see obituary, Geol. Mag., September, 1906, pp. 426–431).

1. Professor S. H. Reynolds' monograph on the Pleistocene Bears is a welcome contribution to our knowledge of the fossil remains of a group of animals widely distributed over the temperate and colder regions of the Northern Hemisphere, and very well represented in the Pleistocene deposits and cave fauna of this country and Ireland.

The author records 33 localities in peat, brickearth, and river deposits which have yielded Bear-remains. Of these only one spot, the brickearth of Barrington, near Cambridge, has furnished undoubted remains of *Ursus spelæus*. Four other doubtful localities are recorded; one of these, Ilford, may possibly prove, like Barrington, to yield remains of this more ancient type of Cave-bear.

Eleven localities are cited in which the 'Brown-bear' (*Ursus arctos*) has been met with, and two others are doubtfully referred to this species.

The 'great Grizzly Bear' (*Ursus horribilis*) is recorded from 14 localities and from 7 others doubtfully.

Our Limestone caves and fissures in 23 localities have yielded genuine remains of *Ursus spelæus* and 3 others doubtfully; whilst 15 caves have yielded *Ursus arctos*, 14 *Ursus horribilis*, and in 5 other localities the species of bear appears to be doubtful.

The author discusses very fully the difficulties which the comparative anatomist encounters in his endeavours to separate specifically the various bears of the *arctos* type, and cites the opinion of A. E. Brown (Proc. Acad. Nat. Sci. Philad., 1894, p. 119) that "a critical survey of the cranial and dental characters shows little that is constant, except variation, and absolutely forces the conclusion that there is not one character sufficiently stable and uniform to be of specific value. The European bear and the grizzly run into one another so regularly that, except in extreme cases, there is no possibility of distinction apart from geographical considerations."

"The differences," writes Professor Reynolds, "separating the cave bear (*Ursus spelæus*) from the others are certainly greater than those between the different bears of the *arctos* type, but, unless perhaps in the case of $\overline{\text{pm. 4}}$, it is doubtful whether they are sufficiently marked and constant to afford specific distinctions. Certainly all the species of Pleistocene bears are closely allied and tend to run into one another, and it is perhaps not a matter of much practical importance whether they are grouped as one, two, or three species. On the whole it has seemed most satisfactory to recognise the specific distinction of *U. spelæus*, while grouping all the other Pleistocene bears as *U. arctos*." (p. 32.)

2. Dr. R. H. Traquair continues his monograph on the Fishes of the Old Red Sandstone of Britain, and deals with the curious genus *Bothriolepis*, a restored outline by the author of the dorsal surface of *B. hydrophila* being given on p. 125, and five plates, which furnish the details of a number of historical specimens, including those from the famous Hugh Miller Collection.

3. Mr. Henry Woods continues his most desirable work on the Cretaceous Lamellibranchia of England, dealing in the present part with the Pinnidæ, Astartidæ, Carditidæ, Crassatellitidæ, and Cyprinidæ. The 8 plates, by Mr. T. A. Brock, illustrating these

families of Cretaceous bivalves, are most excellent, and their processing and printing by the London Stereoscopic Co. most praiseworthy.

4. Mr. F. R. Cowper Reed contributes a third part of his monograph upon Girvan Trilobites (Lower Palæozoic) from Mrs. Gray's collection. This collection of fossils, from the Ordovician and Silurian rocks of Girvan, Ayrshire, has already engaged the attention of the late Dr. Thomas Davidson (who studied the Brachiopoda), of Professor Lapworth, Professor H. A. Nicholson, Mr. Etheridge, and several other well-known palæontologists, and is now occupying Mr. Reed's attention in describing the Trilobites. It will be remembered that on February 20th, 1903, the Council of the Geological Society awarded the balance of the Murchison Fund to Mrs. Gray in recognition of her labours during very many years in carefully collecting the fossil remains of this district, thus giving to her collection the mark of the Society's approval and commendation. The careful gathering together of the fossils from a given horizon and locality cannot fail to be of the very greatest value to palæontological science. Seven plates, comprising figures of the genera *Lichas*, *Acidaspis*, *Encrinurus*, *Cybele*, *Dindymene*, *Calymene*, *Cheirurus*, *Phacops*, *Asaphus*, *Cyclopyge*, *Ampyx*, and *Illænus*, well executed by Miss G. M. Woodward, illustrate the subject of the present memoir.

5. Mr. Philip Lake commences a monograph of the British Cambrian Trilobites in this volume, which will carry on the work so long left unfinished by the late J. W. Salter. This will be of great importance to collectors and geologists, as the Trilobites occupy so large a place in the fauna of the Palæozoic rocks, and are also extremely valuable in marking off the horizons of the older rocks. Two plates only of the genus *Agnostus* accompany the present part, but they are extremely good illustrations of process-reproduction.

6. The sixth and final memoir is by Miss Gertrude L. Elles, Sc.D., and Miss Ethel M. R. Wood, D.Sc. (now Mrs. Shakespear). These ladies, with the assistance of Professor Lapworth, have reached the fifth part of their monograph, and now deal with the species of the genus *Climacograptus*, illustrated by two plates and numerous text-figures. All workers at this difficult group, the specimens of which are often very obscurely to be seen upon the surfaces of black shale, will be most thankful to the authors for the great pains they have bestowed upon the delineation and description of these organisms, which, when accurately determined, prove of such value to the stratigraphical geologist in fixing the various horizons of the very complex series of older formations of which they are the unerring landmarks and guides.

We commend the work carried on by the Palæontographical Society to the attention of all students of geology, feeling sure that its monographs need only to be known in order to secure new annual subscribers, the better to carry on successfully the important and most valuable work of illustrating and describing every British fossil, and thus to aid in the progress of Palæontology. We may add that Dr. Arthur Smith Woodward, F.R.S., the Secretary, will be happy to receive the name of new subscribers *at any time*. His address is Natural History Museum, Cromwell Road, London, S.W.

II.—THE GLACIAL HISTORY OF NANTUCKET AND CAPE COD: WITH AN ARGUMENT FOR A FOURTH CENTRE OF GLACIAL DISPERSION IN NORTH AMERICA. By J. HOWARD WILSON, A.M., Ph.D. x + 90 pp., with 38 plates (29 photographic views and 9 maps) and 13 text-figures. (New York, The Columbia University Press; London, Macmillan & Co.: 1906. Price not stated.)

THIS book, issued as No. 1 of the Columbia University Geological Series, is essentially a geological 'paper' of the usual type, published in a form unusual in this country. It is well printed on thick unglazed paper, profusely illustrated, and neatly bound; but the subject-matter, though scientifically valuable, is of comparatively restricted interest, and except in the United States would not have been deemed sufficient either in quantity or substance to reach the dignity of separate publication in this form.

The paper deals exhaustively with the glacial deposits—the only visible formation — of the small island of Nantucket and of the adjacent peninsula of Cape Cod, with notes on other islands in the neighbouring part of the Massachusetts coast. This area had been previously investigated by Shaler, Woodworth, and others, but the author believed that the field was rich enough to yield a second crop. The principal outcome of his work is the theoretical conclusion—of interest mainly to the American glacialist—that the latest glaciation of the region was effected by an ice-sheet radiating from a hitherto unrecognized centre, lying to the east of the Labrador sheet and moving south-westward to the Massachusetts coast from Newfoundland.

The shelly drift of Sankaty Head, Nantucket, receives particular notice, the author having obtained by excavation a large series of shells and a fully detailed section of this stratified deposit of sand and gravel. He has previously published an account of this work in the *Journal of Geology* (Nov.–Dec., 1905), his conclusion being that the beds are of normal marine accumulation, and that although the shelly deposit is only 8 feet in thickness it embraces indications of changing condition; the lower layers containing shells of a shallow-water type and distinctly southern range, while the upper layers denote considerably deeper water and hold a decidedly northern fauna. The shell-beds are supposed to indicate an Interglacial episode, but the evidence on this point is admittedly weak, as the underlying clay is no longer visible; and though considered by the author to be probably of glacial origin, this clay has been assigned by some of the previous workers to the Cretaceous system.

In view of the much-discussed problem as to the level of the land during the Glacial period, it is interesting to note that "from evidence gathered all over the island we know that the land stood not far from its present level when the ice-front occupied the Nantucket position" (p. 30).

In his general discussion of the drift, the author recognizes as the principal features in Nantucket geology — (1) a chain of "Kame Hills," evidently an old line of moraine, which does not, however, mark the extreme limit reached by the ice-sheet; (2) "the fosse," a low area in front of the Kame Hills, supposed to have resulted from the presence of the marginal ice; (3) "the ice-contact slope," rising above the fosse at the side opposite to the Kame Hills: "here the ice-front rested as the apron-plain developed in front from the overwash, and this slope thus marks the actual front of the ice at any point" (p. 31); and (4) "the apron-plain," sloping gently away from the top of (3) and built up of sandy and gravelly material by streams issuing from the front of the glacier. These features are traced across Nantucket, though not uninterruptedly; and their general aspect is well shown in numerous photographic plates. Of these features the first and the last may be recognized in the lowland drifts of many parts of our own Islands; but "the fosse" and "the ice-contact slope" appear to be unknown, or at any rate have hitherto escaped recognition. In the interpretation of drift-features, however, so much depends upon the foreknowledge of the investigator, that if the attention of our glacialists be turned to the search it is possible that some representative configuration may yet be found in our drifts, though likely, in any case, to be of local and restricted occurrence.

The presence of a fresh-water lake ("Lake Shaler") held in between the lobes of the retreating ice-sheets, is postulated to explain the late-glacial phenomena of the Cape Cod region; and a full consideration of this matter occupies one of the later chapters of the book. Finally, the treatise, thesis, or book contains a lengthy bibliography, but no index.

G. W. L.

III.—ON A SECTION IN A POST-GLACIAL LACUSTRINE DEPOSIT AT HORNSEA. By T. SHEPPARD.[1]

DURING the past few years the various sections in post-glacial lake-beds on the Holderness coast have disappeared, as a result of the erosion of the cliffs, and it has been exceedingly difficult to obtain details of the various beds in consequence. During the Spring of the past year, however, several on-shore gales resulted in a sea-wall in front of the promenade at Hornsea being demolished, behind which was exposed an exceptionally fine series of clays, marls, peat, and gravel, representing the bed of an ancient mere. This was evidently at one time beneath a sheet of water similar to the present Hornsea Mere. Lists of remains of plants, fresh-water shells, Coleoptera, etc., are given, and the fauna and flora of the old and modern meres compared.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

January 23rd, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communication was read:—

"On the Geology of the Zambezi Basin around the Batoka Gorge (Rhodesia)." By George William Lamplugh, F.R.S., F.G.S. With Petrographical Notes by Herbert Henry Thomas, M.A., B.Sc., F.G.S.

This paper contains an account of the physiographical and geological structure of the hitherto undescribed country bordering the Batoka

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[1] A paper read in Section C (Geology) at British Association Meeting, York, 1906.

Gorge, which was investigated by the author in 1905, under the auspices of the British Association.

The physical features of the country fall into two well-marked divisions:—(1) The unbroken plateau, a portion of the great central basin-plain of South Africa. (2) The area of rejuvenated drainage, a wedge-shaped tract having its apex at the Victoria Falls, due to the lowering of the trunk-drainage by the erosion of the deeply cut gorge.

The following rock-systems are described:—

5. Kalahari Sands, Chalcedonic Quartzite, and other surface-deposits.
4. Flaggy Sandstone of Boomka.
3. Batoka Basalts.
2. Wankie Sandstones and Coal-measures (= Matobola Beds and ? Escarpment Grits of Molyneux).
1. Fundamental Complex of Metamorphic and Igneous Rocks.

(1) The Fundamental Complex was studied *in situ* only at one point, near the Wankie Coal-mine. The position of its outcrop north of the Zambezi is inferred from the character of the river-borne detritus in some of the stream-beds.

(2) The Wankie Series consists of massive sandstones and pebbly grits, containing boulders near the base, with intermediate flaggy sandstones and shales with coal-seams. This series is abruptly truncated on the south-east side, along the Deka River, by a great fault which brings in the Batoka Basalts; but reasons are given for supposing that beds of similar character reappear at the northern margin of the Basalts, north of the Zambezi, beyond the district examined.

The Deka Fault is described in some detail, and its important influence upon the structure of the country is discussed. It is suggested that the 'Sijarira Quartzites' of Molyneux, of the country farther to the north-east, may be only the indurated and contorted sandstones that accompany this great fault.

(3) The Batoka Basalts were found to extend unbrokenly from the Victoria Falls eastward to the mouth of the Deka, and southward to the edge of the Kalahari Desert; and it is shown that they also cover a very wide area to the southward and westward of the region traversed. They consist of a succession of massive lava-flows and flow-breccias; no intercalated sediments were found in the districts examined, nor was any eruptive centre discovered. Some curious structures observed in basalts are described; and it is remarked that the zigzagging character of the stream-gorges below the Victoria Falls is due to the differential erosion along the strong joints and fault-planes in these rocks, under the alternating conditions of wet and dry seasons.

The age of the Basalts is discussed, and it is considered that they are probably Mesozoic, and may date back to the later stages of the period of volcanic activity represented by the Stormberg Beds of the more southerly part of the continent.

(4) Some limited patches of Flaggy Sandstone, etc., seen near the head of the Deka Basin, appear to represent sediments newer than the Basalts, and may be equivalent to part of the Forest Sandstone of Mr. A. J. C. Molyneux and Mr. F. P. Mennell.

(5) The 'Kalahari Sands,' which cover large areas of the plateau, occur mainly in broad low swells or 'bults' of friable red sand, now tree-clad. These sweep down to the Zambezi River in the shallow valley above the Victoria Falls, and cannot have been accumulated under existing conditions. The author endorses Dr. S. Passarge's view that they indicate a former period of greater aridity than the present in the Central Basin.

Some irregular patches of surface quartzite and limestone, due to the percolation and evaporation of ground-water, are described and compared with the 'Botletle-Schichten' (Passarge) of the Kalahari, but the author considers that the antiquity of these beds is not so great as that assigned to the 'Botletle-Schichten.'

The paper concludes with a petrographical appendix by Mr. H. H. Thomas, giving the results of his microscopic examination of a series of rock-specimens collected by the author.

CORRESPONDENCE.

THE ASHGILLIAN SERIES.

SIR,—In connection with Dr. Marr's paper on the Ashgillian Series in this month's GEOLOGICAL MAGAZINE, it may be of interest to call attention to some further evidence of the age of the Starfish Bed in the Drummuck Series of Girvan which he correlates with the *Staurocephalus* Limestone of the north of England and Wales. To the list of trilobites from this bed which I have recently given in my monograph on the Lower Palæozoic Trilobites of the Girvan District (Palæontographical Society, 1903–1906) there may now be added the two species *Cheirurus Keisleyensis*, Reed, and *Ampyx binodulosus*, Reed, described by me in 1896 from the Keisley Limestone. Mrs. Gray collected these specimens within the last few months, and they have only lately come into my hands for identification. The affinities of the trilobitic faunas of the Keisley Limestone and Starfish Bed which had been previously observed are appreciably strengthened by these new discoveries. F. R. C. REED.

SEDGWICK MUSEUM, CAMBRIDGE.
February 20th, 1907.

OBITUARY.

EDWARD BEST.

BORN DEC. 20, 1824. DIED NOV. 8, 1906.

WE regret to record the death on November 8th, 1906, of Edward Best, who for more than thirty-eight years was Resident Geologist to the Geological Survey in Jermyn Street. Born on the 20th December, 1824, he joined the service in January, 1855, shortly before De la Beche died, and he retired on March 31st, 1893. Although he never took a profound interest in geology, he was ever ready to give help to those who sought information at the Geological Survey Office, while his ever cheerful disposition and *bonhomie* endeared him to all who came to know him.

JOHN WARD, F.G.S.

Born August 11, 1837. Died November 30, 1906.

The death of Mr. John Ward, of Longton, Staffordshire, removes from the Midlands one of its best known and most active geologists and palæontologists. Mr. Ward devoted the leisure of his busy life to a detailed study of the North Staffordshire Coalfield and its fossils. He was a pioneer in the collection of fossils to illustrate accurately their zonal distribution; and he met with great success not only in unravelling the stratigraphy of the Coal-measures, but also in the discovery of a large number of well-preserved fossil fishes, which were new to science and contributed to a great advance in our knowledge of Palæozoic Ichthyology.

Mr. Ward was born at Fenton, North Staffordshire, in 1837, and was educated at Ivy House School, Hanley. Early in life he entered on a business career, which occupied him until the end, and only left him scanty leisure for the pursuit of studies. When quite young, he came under the influence of Dr. Robert Garner (author of the well-known "Natural History of the County of Stafford," 1844), who encouraged him in the geological researches which became the main recreation of his life. In 1865 he attended the meeting in Stoke at which the North Staffordshire Field Club was established, and continued for forty years to be one of its most active members.

Mr. Ward's geological researches had as their chief aim the identification and correlation of the more important coal-seams of North Staffordshire by their fossils; and one of his earliest discoveries was that of marine bands intercalated at definite horizons in the Coal-measure series. His observations were first summarised in 1890 in his exhaustive volume on "The Geological Features of the North Staffordshire Coalfields," published by the North Staffordshire Institute of Mining Engineers. His final conclusions formed the subject of some valuable chapters on the "Palæontology of the Pottery Coalfield," which he contributed to the Geological Survey Memoir in 1905.

Mr. Ward was also an accomplished palæontologist and made many important observations on the fossils in his collection, but he rarely attempted palæontological descriptions. His fossil fishes were studied and described by Egerton, Huxley, John Young, James W. Davis, Dr. Traquair, and the present writer, some of the most important researches of Dr. Traquair having been based almost entirely on the specimens obtained from the Coal-measures of Longton and Fenton. Mr. Ward's name, however, is permanently associated with his discoveries in numerous instances, such as those of *Acanthodes Wardi*, *Listracanthus Wardi*, *Mesolepis Wardi*, *Rhadinichthys Wardi*, and others. The Lower Carboniferous Platysomid genus *Wardichthys* is also named after him.

When, by the closing of certain coal-pits, opportunities for collecting fossil fishes became fewer, Mr. Ward decided to offer his collection to the British Museum, and the principal part of it was purchased by the Trustees in 1894. After that year he devoted attention more especially to the Mollusca and Plants, which were described respectively by Dr. Wheelton Hind and Mr. R. Kidston; though he still never neglected any opportunity of obtaining fish-remains, and among these his latest most important discovery was that of a new *Listracanthus* in direct association with the so-called *Petrodus*.[1]

Mr. Ward was elected a Fellow of the Geological Society in 1874, and received a moiety of the Lyell Fund from that Society in 1899 in recognition of the value of his long-continued researches. In 1895 the North Staffordshire Field Club also honoured him by the award of the Garner Memorial Medal. Only a small proportion of Mr. Ward's work, however, is embodied in his published writings. He was an unassuming and unselfish, enthusiastic student, whose knowledge was at the disposal of everyone who went to consult him. The little library in the room above his shop, and the dark basement in which he kept his collection for so many years, were the familiar haunts of all who were interested in the English Coal-measures. His robust physique enabled him to participate in active field-work almost until the end of his life, and he was always ready to accompany enquirers to any part of the district he knew so well. His genial presence will be missed by a large circle of friends who mourn his loss.

A. S. W.

LIST OF PAPERS BY JOHN WARD, F.G.S.

1861. "Fenton Park: its Ichthyolite Remains": Potteries Mechanics' Mag., vol. ii, p. 137.

1865. Letters on "Marine Fossils in Coal-measures": GEOL. MAG., Dec. I, Vol. II, pp. 234, 286.

"The Distribution of the Organic Remains of the North Staffordshire Coal-field": Trans. Dudley and Midland Geol. Soc., vol. ii, p. 21.

1870. "Notes on the Fossil Trees in Messrs. Hampton's Marl Pit at Joiners' Square, Hanley": Rep. N. Staffs. Nat. Field Club.

"The Fossil Fishes of the North Staffordshire Coalfield": Trans. Midland Sci. Assoc., pt. ii.

1875. "Notes on the Fossil Trees in a Marl Pit at Hanley": Addresses and Papers N. Staffs. Nat. Field Club, pp. 80–86.

"On the Organic Remains of the Coal-measures of North Staffordshire, their Range and Distribution, with a Catalogue of the Fossils and their Mode of Occurrence": loc. cit., pp. 184–251, with plate.

1878. "Notes on some Fossil Trees in a Marl Pit at Joiners' Square, near Hanley": Rep. N. Staffs. Nat. Field Club.

1880. The same, with further notes: loc. cit.

1889. "The Lower Coal-measures of the Cheadle Coalfield, with Special Reference to the Recent Boring for Ironstone at the Park Hall Colliery, Cheadle": loc. cit., pp. 88–91.

1890. "The Geological Features of the North Staffordshire Coalfields; their Organic Remains, their Range and Distribution, with a Catalogue of the Fossils of the Carboniferous System of North Staffordshire": Trans. N. Staffs. Inst. Mining Engineers, vol. x, pp. 1–189, pls. i–ix.

1893. "The Progress of Geological and Palæontological Research in North Staffordshire, with Summary of Literature relating to the Geology, Mineralogy, and Palæontology of North Staffordshire": Trans. N. Staffs. Nat. Field Club, vol. xxvii, pp. 67–107 (continued in vol. xxix, 1895, pp. 105, 106).

1895. "On the Occurrence of Marine Fossils in the Coal-measures of North Staffordshire": loc. cit., vol. xxix, pp. 129–138.

1900. "On a newly-discovered Marine Bed in the Coal-measures of North Staffordshire": loc. cit., vol. xxxiv, pp. 87–92.

1905. "Palæontology of the Pottery Coalfield": in "The Geology of the North Staffordshire Coalfields," Mem. Geol. Surv.

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[1] A. S. Woodward, "On the Carboniferous Ichthyodorulite *Listracanthus*": GEOL. MAG., Dec. IV, Vol. X (1904), pp. 486–488, with figs.

1906. [With John T. Stobbs.] "A newly-discovered Fish Bed in the Cheadle Coalfield; with Notes on the Distribution of Fossil Fishes in that District": Trans. N. Staffs. Nat. Field Club, vol. xl, pp. 87–101, pl. i.
"Palæontology of the Cheadle Coalfield": loc. cit., vol. xl, pp. 102–137, pl. ii.

CAROLINE BIRLEY.

Born November 16, 1851. Died February 15, 1907.

By the death of Miss Caroline Birley a most ardent and enthusiastic student has been lost to the science of Geology, one who from her childhood to the end of her life never wavered in devotion to this her cherished pursuit, nor thought any fatigue or personal sacrifice too great in order to visit places of geological interest and obtain specimens for her beloved Museum.

Caroline Birley was the youngest daughter of Mr. Thomas Hornby Birley, who resided at Hart Hill, near Manchester. When a child her holidays were constantly spent in the Isle of Man, where her grandfather, Lieut.-Col. Leatham, resided after his retirement from the Army. Her earliest delight was to select specimens of stones showing any peculiarity, and when about 9 years of age she commenced to form a collection, to which she continued most assiduously to add when travelling in England or on the Continent. When the Geological Magazine commenced its existence in 1864 this young enthusiast of 13 years of age became a regular monthly subscriber, devoting her pocket-money to this periodical! After a year of self-denial her grandmother, discovering this sacrifice to the cause of geological science, made her granddaughter a special allowance to purchase this coveted journal.

In the year 1888 Miss Caroline Birley's collection had already outgrown the space in her house at Seedley Terrace, Manchester, and she erected an iron building in the garden as a museum. In 1888 Miss C. Birley visited Faxe, Denmark, and again in the Summer of 1891, when she made a large collection of Upper Cretaceous fossils. The Crustacea thus obtained were described by Dr. H. Woodward in the Geological Magazine for November, 1901 (pp. 486–501, Pl. XII). Two new species of the genus *Dromiopsis* (*D. Birleyæ* and *D. Coplandæ*) obtained in that expedition were figured and described by him, and dedicated to Miss C. Birley and her friend and fellow-traveller, Miss L. Copland.

In June, 1889, Miss Birley and her friend Miss Copland visited the Færoes, bringing back from the islands of Stromoe, Naalsoe, and Osteroe six hundredweights of rocks containing zeolites. In 1890 she paid a second visit to the Færoes. In that year Miss Birley became a member of the Geologists' Association, to the excursions and meetings of which Society she was always afterwards a very constant attendant. She also, later on, in 1894, joined the Malacological Society of London, and frequently attended its meetings. In November, 1891, Miss Birley and Miss Copland went to Malta and did a considerable amount of collecting from the Tertiary strata of that island. In 1892 the ladies visited Algeria, but did not succeed in making a very large collection there.

In 1896 Miss Birley settled in London, taking up her residence at No. 14, Brunswick Gardens, Kensington, W., to which house she also transferred her museum.

Having joined the British Association at Manchester in 1887, Miss Birley regularly attended its subsequent meetings and always attached herself to the Geological Section and its excursions. In 1897 she went to Toronto with that body, and in a trip to Colorado obtained some excellent minerals. In 1899 a visit was paid to the Azores with the intention of collecting from the fossiliferous beds in Santa Maria, but insuperable obstacles intervened, and they were unable to reach that island from St. Michaels. In 1902 a collection was made from the Kimmeridgian and Oxfordian of the neighbourhood of Boulogne.

Miss Birley's last long expedition was to attend the British Association at Cape Town in August, 1905, accompanying it in all its travels as far as the Victoria Falls. In that year she placed in the hands of Mr. R. Bullen Newton, F.G.S., for description, a series of fossiliferous nodules from the beach off the Ormara Headland, facing the coast of Baluchistan in the Indian Ocean. These nodules, which contained numerous Tertiary mollusca, were figured and described in detail by Mr. Newton in the pages of the GEOLOGICAL MAGAZINE for July, 1905, pp. 293–303, Pls. XVI and XVII, to which Mr. Burrows added a notice of a Bryozoan (op. cit., pp. 303–305) with a text-figure; and Dr. H. Woodward described a new Crab (*Neptunus Arabicus*) and a group of *Balani*, of which he gave figures (op. cit., pp. 305–310).

A new genus and species of Crustacean, obtained by Miss Birley from the Gault of Folkestone in 1900, was described by Dr. H. Woodward under the name of *Mesodromilites Birleyæ* (see GEOL. MAG., 1900, pp. 61–64, with text-figure).

Miss Birley spent very much of her time in the Geological and Mineralogical Galleries of the British Museum naming her specimens, upon the arrangement of which she spared no labour or expense. Last year she was far from well, but her courage was so indomitable that she attended the meeting of the British Association at York in August last. In the Autumn she had a severe illness, after which she never regained her usual strength; but she continued to arrange and label her more recent acquisitions, and retained her interest in her museum to the end. Her last addition consisted in a large slab of New Red Sandstone from the Stourton Quarries, Cheshire, with Labyrinthodont footprints upon its surface.

After a week's illness from influenza this ardent geologist succumbed to heart-failure on the 15th February, 1907. We believe she has given directions that the best specimens in her collection are to be presented to the Trustees of the British Museum, for the Geological and Mineralogical Collections of the Natural History Branch in Cromwell Road, with remainder to the Manchester Museum, in the Owen's College, Manchester.

Miss Caroline Birley was buried at Lingfield Church, Surrey, on Tuesday, the 19th February, near the home of her brother, Mr. Francis Hornby Birley.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. IV.—APRIL, 1907.

ORIGINAL ARTICLES.

I.—A Case of Metamorphism of Chalk.

By Geo. C. Gough, A.R.C.S., B.Sc., F.G.S.,
Professor of Natural History, Royal Agricultural College, Cirencester.

(PLATE V.)

CASES of metamorphosed limestones where the calcium carbonate has been converted by contact with some igneous magma into a calc-silicate rock are by no means rare, one of the best known being the conversion of the Coniston Limestone of the Lake District by the Shap Granite into a rock with various calc-silicate and other minerals such as Wollastonite, Omphacite, etc., as described by Messrs. Harker and Marr.[1] But as far as I know, no case has been recorded where ordinary white chalk has been similarly changed. Dr. Hibsch[2] describes a case of baculite marl containing Foraminifera which has been altered by contact with dolerite. The Foraminifera disappear and the rock becomes a granular limestone with epidote, forming a calc-silicate hornstone. This seems the nearest case to the alteration in co. Antrim I am about to describe.

As most geologists know, the Irish Chalk is considerably harder than the English variety, due, it is usually considered, to the baking action of the overlying basalts, although this idea is far from being generally accepted. In places it is not uncommon for dykes to have penetrated the chalk and to have altered it at the point of contact to crystalline limestone. Nearly a century ago Berger[3] stated that "the chalk is frequently traversed by basaltic dykes, and often undergoes a remarkable alteration at the point of contact. The change sometimes affects 10 to 12 feet from wall of dyke, gradually decreasing from the dyke. The extreme effect presents a dark-brown crystalline limestone, the crystals running in flakes as large as those of coarse primitive limestone, etc." Other instances of the disappearance of the organisms and the production of crystals of calcite could be quoted.

In 1904 Miss M. K. Andrews, of Belfast, while examining the altered chalk at Scawt Hill, an old volcanic neck, about 6 miles north of Larne, came upon a dyke traversing the 'neck' dolerite of the hill and cutting across a narrow band of chalk. The geological structure of the district is that common to the basaltic plateau of Antrim, and consists of the basic lava-flows covering the Chalk and other Mesozoic beds, the chalk being the usual hard variety of Ireland. Of this hill the Irish Survey Memoir to Sheet 20 states that "at Slieve Scawt the Chalk has been carried up with the basaltic mass forming the volcanic neck. By igneous action it has been converted into a highly crystalline saccharoidal marble." Miss Andrews informs me that "the band of chalk appears to project horizontally into the 'neck'; and the dyke, which is between 3 and 4 feet wide, is running vertically through the 'neck' cutting across the tongue of chalk." The chalk had weathered so much that it was quite unexpectedly that she came upon the dyke. Miss Andrews obtained various samples from different points, and after having sections cut kindly handed them over to me. The specimens include (i) the rock forming the 'neck' and which she thinks has carried up the chalk; (ii) the dyke which runs through the neck; and (iii) the chalk in various stages of metamorphism.

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[1] Q.J.G.S., 1891.
[2] Verhandlungen Geol. Reichsanstalt, 1889, p. 204.
[3] Trans. G. S., vol. iii.

Number I, may be dismissed very briefly, as it is one of the typical igneous rocks of the district, namely, a fine-grained ophitic dolerite. It is holocrystalline, the minerals being augite, felspar, olivine, and magnetite. The augite is in rather large pale-brown non-pleochroic crystals, broken up by longish lath-shaped crystals of plagioclase which appear to be labradorite. The olivine is roughly idiomorphic, generally clear and colourless, but changed to yellow serpentine along the cracks.

Number II (Pl. V, Fig. 1), the dyke, proves to be a very interesting rock. It is a granitoid, holocrystalline, basic rock, and may perhaps be best classed with Harker's "diabases without olivine," although its granitoid structure would almost lead one to call it a gabbro. Its most striking feature is its beautifully pleochroic augite, which is found in well-marked eight-sided crystals. These augites are apparently titaniferous, with a pleochroism varying from a dark lilac to yellowish green and frequently showing the hour-glass structure. They are well-zoned, and in some cases show undulating extinction, but in the majority of crystals, although there is a well-marked outer zone suggesting a different composition, it extinguishes at practically the same angle as the main mass of the crystal. The felspar has decomposed, and is filled with feathery and radiating decomposition products, so that it is not possible to distinguish the variety. No olivine was detected, but a little interstitial quartz was found, while apatite in small but well-marked prisms is fairly frequent. Iron-ores are also plentiful, the chief being magnetite, in places having a kind of reaction rim of actinolite (?); ilmenite is present, as is also pyrite.

The first noteworthy change in the chalk is seen in a section from 20 yards away from dyke. Here the organisms have disappeared, and the chalk has become finely granular owing to the development of fine crystals or grains of calcite. About two yards from dyke the chalk has become a typical crystalline limestone with large crystals of calcite showing well-marked lamellar twinning and rhombohedral cleavage. One section shows small flakes of mica which are probably phlogopite.

Adjoining, and also caught up in, dyke is a rock which weathers so dark that it is difficult to tell it, except on a freshly fractured surface, from the dyke. It is found on microscopic examination to be the chalk completely altered into what may be termed a Calc-Silicate Hornstone, and specimens from different positions, while coming under this name, show different proportions of the minerals present. The size of the constituent crystals also varies from rather finely granular ones, mutually interfering, to larger well-marked crystals which are in places idiomorphic. The minerals found in the various specimens may be enumerated preparatory to a description of the rock. They are Wollastonite, Scapolite, Zoisite, Calcite, Diopside, Anorthite, and Magnetite. I strongly suspect Ilmenite as being present, but I could not prove it by chemical tests, while another mineral seen in sections as tiny, idiomorphic, octahedral, yellowish-brown, isotropic crystals is possibly Perofskite, but as I did not find it in the crushed rock I could not be certain of its identification. Garnets were specially looked for, but not detected, nor were any coloured minerals present such as Idocrase or Epidote.

The identification of the various minerals in the sections is by no means easy, as with the exception of the magnetite they are clear and colourless, and only in rare cases did they give figures in convergent light sufficiently good to obtain the sign. It was, however, obtained with most of the minerals, but specimens of the rock were also crushed, sieved, and separated by methylene iodide. Separation was also done, and the specific gravity of the minerals obtained, by means of the diffusion column and confirmed by the refractive index, and in the case of diopside by the micro-chemical test for magnesium.

The first specimen examined is chiefly composed of two minerals, one of which is of a different refractive index from the other. Both are biaxial, and were found to be wollastonite and diopside. Further search revealed grains of a negative uniaxial mineral which proved to be scapolite. A little magnetite is scattered through the section, while anorthite is also present in small quantity. Another section from near the above shows crystals of a larger size, and in places crystals of calcite have enclosed idiomorphic crystals of other minerals in a pœcilitic fashion (Pl. V, Fig. 3). These latter include long crystals, about three times as long as broad, of zoisite, having a rough cross parting, low polarization colours, and a high refractive index. They frequently show twinning in plane polarized light. Scapolite with a negative uniaxial figure, straight extinction, and moderately bright polarization colours is also to be seen with good crystal outlines, as is wollastonite with still brighter colours. Magnetite is scattered rather thickly throughout the section.

A third specimen is interesting as it shows a section of the rock with the magnetite almost absent from one half and thickly scattered over the other half (Pl. V, Fig. 2). All the above-mentioned minerals are present in some part of the section, but the grouping is very variable.

With regard to the cause of this particular alteration of the chalk, I cannot say much as I have not analysed specimens of the unaltered chalk. According to Hume's analyses,[1] the white limestone (Upper Chalk) that he analysed did not contain more than one per cent. of impurity, and this would not be enough to supply the silica in the metamorphosed rock. That the dyke supplied the heat necessary, that is, that the metamorphism took place subsequently to the formation of the 'neck,' I feel convinced, as the conversion of chalk into crystalline limestone is chiefly found in connection with dykes later than the chief outflow of lava over the county, and I can only suggest that there has been a mixture of the dyke with the chalk in different proportions. This would explain the varying mineral composition of the different specimens, the iron of the ferro-magnesian minerals being thrown out in the form of magnetite, the magnesium going to form the diopside. The parts where there was an abundance of magnetite would be those with the largest amount of mixture with the dyke.

In conclusion, I should like to thank Miss M. K. Andrews for the loan of sections and specimens, Drs. Cullis and Flett for advice and suggestions, and Mr. Waldron Griffiths, of Cirencester, for the microphotographs illustrating this paper.

EXPLANATION OF PLATE V.

Fig. 1.—Diabase: Scawt Hill, co. Antrim. × 15. The zoning of the augites is well seen on the right in the two long crystals. The lighter part seen in the section is felspar; iron-ores are black and opaque, while apatite is seen in six-sided section.

Fig. 2.—Calc-silicate Hornstone: Scawt Hill. × 15. This shows the difference due to the varying amount of magnetite present and the sharp line marking off one part from the other.

Fig. 3.—Calc-silicate Hornstone: Scawt Hill. × 25. The idiomorphic character of some of the minerals is well seen near the centre of the section, where wollastonite, zoisite, and scapolite are enclosed by the clear calcite.

II.—Note on the Geological Age of the Shales of the Parys Mountain, Anglesey.

By G. J. Williams, M.I.M.E., Assoc. Inst. M.M., F.G.S.

THE rocks of the Parys Mountain, which lies about two miles to the south of the town of Amlwch in Anglesey, were described in 1878 by the late Mr. T. Fanning Evans, H.M. Inspector of Mines, who regarded the Parys Mountain "as an outlying piece of ground, geologically identical with the region in which the great slate-mines of Festiniog occur, and from which it differs only in being developed on a much smaller scale, and in being highly metalliferous."[2]

The Festiniog slate beds are well known to be of Llandeilo age, but at the time Mr. Evans wrote, thirty years ago, little was known of the black shales of North Wales or their fossil contents.

In the second edition of Ramsay's "Geology of North Wales," p. 248, reference is made to a band of very black shale containing

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[1] Q.J.G.S., vol. liii (1897).

[2] Trans. Manchester Geol. Soc., vol. xiv (1878), p. 360.

× 15.

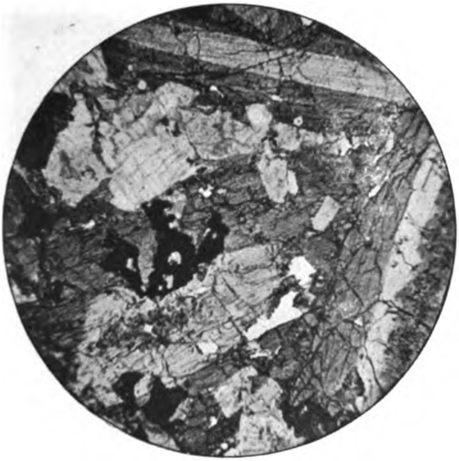

FIG. 1.

× 15.

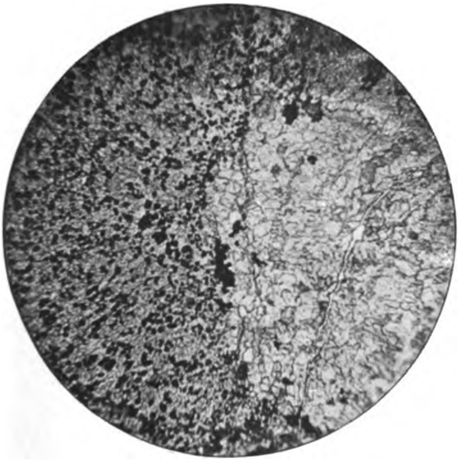

FIG. 2.

× 25.

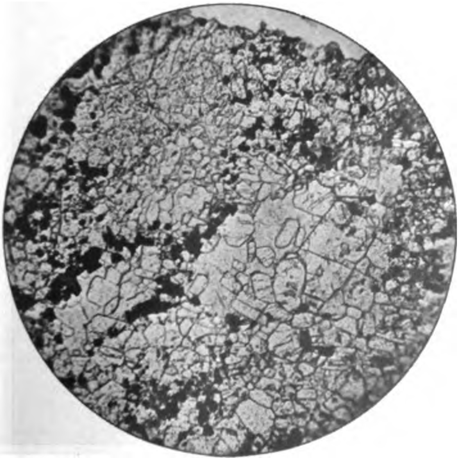

FIG. 3.

Metamorphism of Chalk: Scawt Hill, Co. Antrim.

graptolites, existing between the two principal hard bands of the Parys Mountain, but no list of species is given.

Professor McKenny Hughes, in his second paper on the Geology of Anglesey, refers to "the black shales between the two great felsite ribs" in the Mona Mines of the Parys Mountain as the highest horizon from which he had procured any fossils.[1] The late Mr. Fanning Evans, while searching for fossils in Prof. Hughes' company, "had the good luck to pick up a slab containing no less than eight species of graptolites," of which a list is given, but this appears to have been the only fossiliferous piece discovered.

On several occasions during the last dozen years I have searched for fossils in the shales, but succeeded in obtaining none other than obscure traces till January of last year, when I discovered a number of Llandovery species, and I found others during a visit in the month of May. At this time a tunnel was being driven south in a part of the Mona Mine, between the two "ribs" mentioned above, and it is from this tunnel that the graptolites were obtained. The beds in the tunnel, which is now about sixty yards long, dip generally at an angle of about 45° north, though there occur some contortions and faults. The rocks consist of soft earthy shales, more sandy beds, and a few lenticular bands of a fine-grained, extremely hard rock. In the softer beds the graptolites are but indifferently preserved, while from the more sandy ones many specimens were obtained beautifully preserved in relief. The following is a list of the species which were kindly named for me by Miss Elles, D.Sc. :—

Cephalograptus cometa, Gein.
Climacograptus Törnquisti, Elles & Wood.
Climacograptus sp.?
Diplograptus tamariscus, Nich.
D. sinuatus, Nich.
Monograptus Becki, Lapw.
M. Clingani, Carr.
M. communis, Lapw.
M. convolutus, His.
M. involutus, Lapw.
M. jaculum, Lapw.
M. leptotheca, Lapw.
M. lobiferus, McCoy.
,, ,, *M.* aff. *cyphus*, Lapw.
,, ,, var. *ambiguus*, Törnq.
Petalograptus minor, Elles.
P. palmeus, var. *latus*, Barr.

Miss Elles determines the zone as that of *Monograptus convolutus* (His.), just below the zone of *M. Sedgwickii* (Portl.).

Last August my friend Mr. Edward Greenly, F.G.S., who, as is well known, is making an exhaustive survey of the geology of Anglesey, collected specimens which came from the same tunnel, but farther south, and he kindly allows me to publish a list of the species he obtained, and which, like mine, were named by Miss Elles. They are the following :—

Climacograptus scalaris, His.
Monograptus discretus, Nich.
M. intermedius, Lapw.
M. Sedgwickii, Portl.

and one if not two species of *Diplograptus* which Miss Elles regards as new, and which will be described in the "Monograph of British Graptolites." Mr. Greenly's specimens are from a slightly higher horizon than mine, viz. that of *M. Sedgwickii*, so that in the beds cut through in the tunnel the dip is inverted or there is a downthrow to the south.

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[1] T. McKenny Hughes, "On the Geology of Anglesey," No. 2: Q.J.G.S., vol. xxxviii (1882), p. 27.

Mr. Greenly informs me that he has lately obtained some graptolites of the 'tuning-fork' type a mile or two away on the strike of the Parys Mountain, thus indicating a much lower horizon not far distant.

It is interesting to note that the copper ore of the Parys Mountain, like the lead and zinc ores of Cardiganshire and Montgomeryshire, occur in beds of Llandovery age.

My best thanks are due to Miss Elles for so kindly identifying the graptolites and for her remarks concerning their zonal value.

III.—The Selbornian of Stonebarrow Cliff, Charmouth.

By W. D. Lang, M.A., F.G.S., F.Z.S., of the British Museum (Natural History).

I. *Introductory.*

ALTHOUGH the succession of Cretaceous beds on Black Ven is well known and much has been written on the various members of the series, only cursory references have been made to those on Stonebarrow Cliff on the east of Charmouth, and the lower beds have never been recorded therefrom. A full list of the literature on the geology of this district, including all that has been written on the Selbornian, is given in the Survey Memoir[1] on the "Geology of Sidmouth and Lyme Regis" and another bibliography in the account of the last excursion to Lyme by the Geologists' Association.[2]

The only mention of the lower beds of the Selbornian (i.e. the zone of *Hoplites interruptus*) on Stonebarrow among these papers is that by Jukes-Browne on the Vale of Marshwood[3]: "Taking next a traverse through the southern outliers near the coast, we find the Cretaceous base-line in Black Ven Cliff at about 320 feet above the sea. Thence it rises to about 350 feet in Stone Barrow, and 400 and more on Golden Cap and Langdon Hill, and finally to about 500 feet on Eype Down." But since, two years later,[4] Jukes-Browne, having described the Gault on Golden Cap, says, "the next cliff exposure is in the face of Black Ven," it is reasonable to suppose that he never found the base of the Cretaceous on Stonebarrow, and that his 350 feet is only an estimate. This point is mentioned because here, although it is not claimed that the heights given are other than approximate, the base of the Cretaceous is estimated only at 320 feet, a very little higher than the height given on Black Ven.[5] The reason for this low estimate will be given later. The exact height, however, is of small importance; moreover, it is possible that the whole cliff face in the neighbourhood of the sections may have undergone some slipping and so have made the Gault appear lower than it really is.

It is not surprising if the Gault on Stonebarrow has not been sought with enthusiasm; for the parts of the cliff where it occurs have suffered

[1] H. B. Woodward: "Geology of Sidmouth and Lyme Regis," 1906, pp. 86–88.

[2] Proc. Geol. Assoc., vol. xix (1906), p. 340.

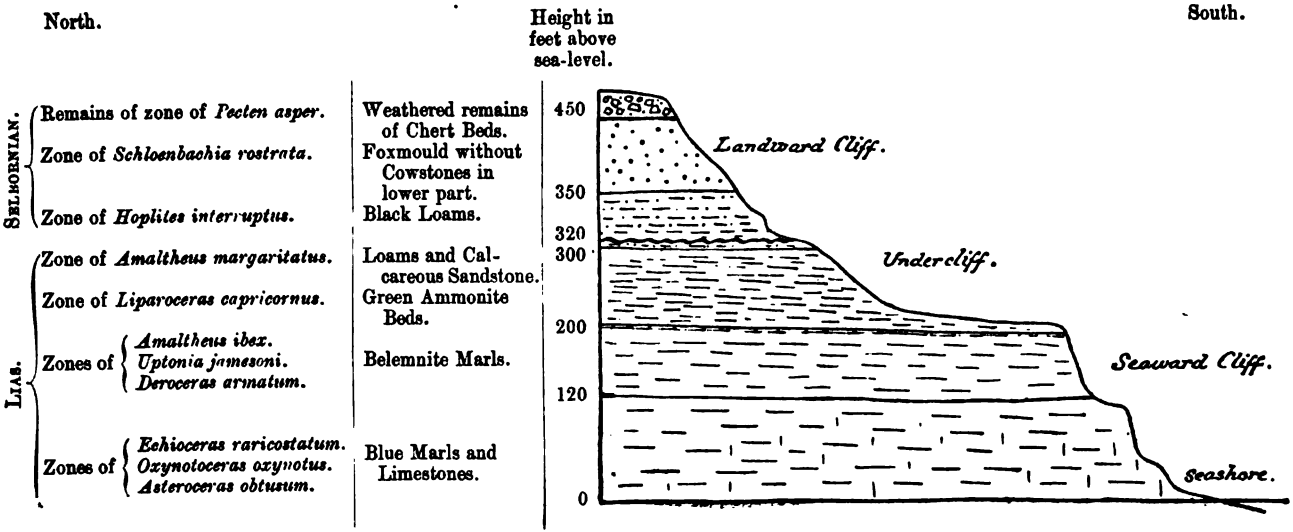
[3] A. J. Jukes-Browne: Proc. Dorset Nat. Hist. Club, vol. xviii (1897), p. 176; Geol. Mag., 1898, p. 164.

[4] A. J. Jukes-Browne, "Gault and Upper Greensand of England," 1900, p. 185: Mem. Geol. Survey.

[5] W. D. Lang, "The Zone of *Hoplites interruptus* at Black Ven": Geol. Mag., 1904, p. 125.

FIG. 1.—GENERAL PROFILE SECTION OF STONEBARROW CLIFF.

This is drawn so as to be exactly comparable with the general section of Black Ven (GEOL. MAG., 1904, p. 127). In both cases the zonal boundaries in the Lias are taken from information in the Survey Memoir (H. B. Woodward, 1893, "Lias of England and Wales"), not from the author's observations.


North.
South.
Height in feet above sea-level.
SELBORNIAN.
Remains of zone of *Pecten asper*.
Zone of *Schloenbachia rostrata*.
Zone of *Hoplites interruptus*.
LIAS.
Zone of *Amaltheus margaritatus*.
Zone of *Liparoceras capricornus*.
Zones of *Amaltheus ibex*. *Uptonia jamesoni*. *Deroceras armatum*.
Zones of *Echioceras raricostatum*. *Oxynotoceras oxynotus*. *Asteroceras obtusum*.
Weathered remains of Chert Beds.
Foxmould without Cowstones in lower part.
Black Loams.
Loams and Calcareous Sandstone.
Green Ammonite Beds.
Belemnite Marls.
Blue Marls and Limestones.
450
350
320
300
200
120
0
Landward Cliff.
Undercliff.
Seaward Cliff.
Seashore.

from great slips and are much overgrown, forming an undercliff of great beauty but offering small hope of exposures. This undercliff, known as Fairy Dell or Cain's Folly, is about 200 yards across at its widest part and some half a mile long; it rises about 100–200 feet from its seaward to its landward margin. It is composed (see Fig. 1) of the upper part of the *capricornus* and of the lower part of the *margaritatus* zones of the Lias and of the lowest beds of the Gault. The actual junction of the Gault with the Lias has not yet been found on Stonebarrow. The seaward margin of the undercliff tops cliffs about 200 feet in height of Lias clays, marls, and limestones, from the *capricornus* down to the *obtusus* zone. Landwards it is backed by Greensand cliffs rising more than 100 feet above the Dell at their highest point.

If the Dell be entered by the footpath leading to it from Charmouth it will be found that the path makes a steep descent of the landward Greensand cliff, and has fallen away before it reaches comparatively level ground. A few yards east of this spot a small bluff is reached, eastward of which the cliff trends more inland. The bluff descends into a small swamp, and the footpath skirts the seaward edge of this. The base of the landward cliff just west of the bluff shows a small section in the Gault. On the eastern side of the bluff, where the landward cliff begins to trend away from the sea, the Gault is again exposed, and is seen to pass upwards into Foxmould sand before the section is broken.

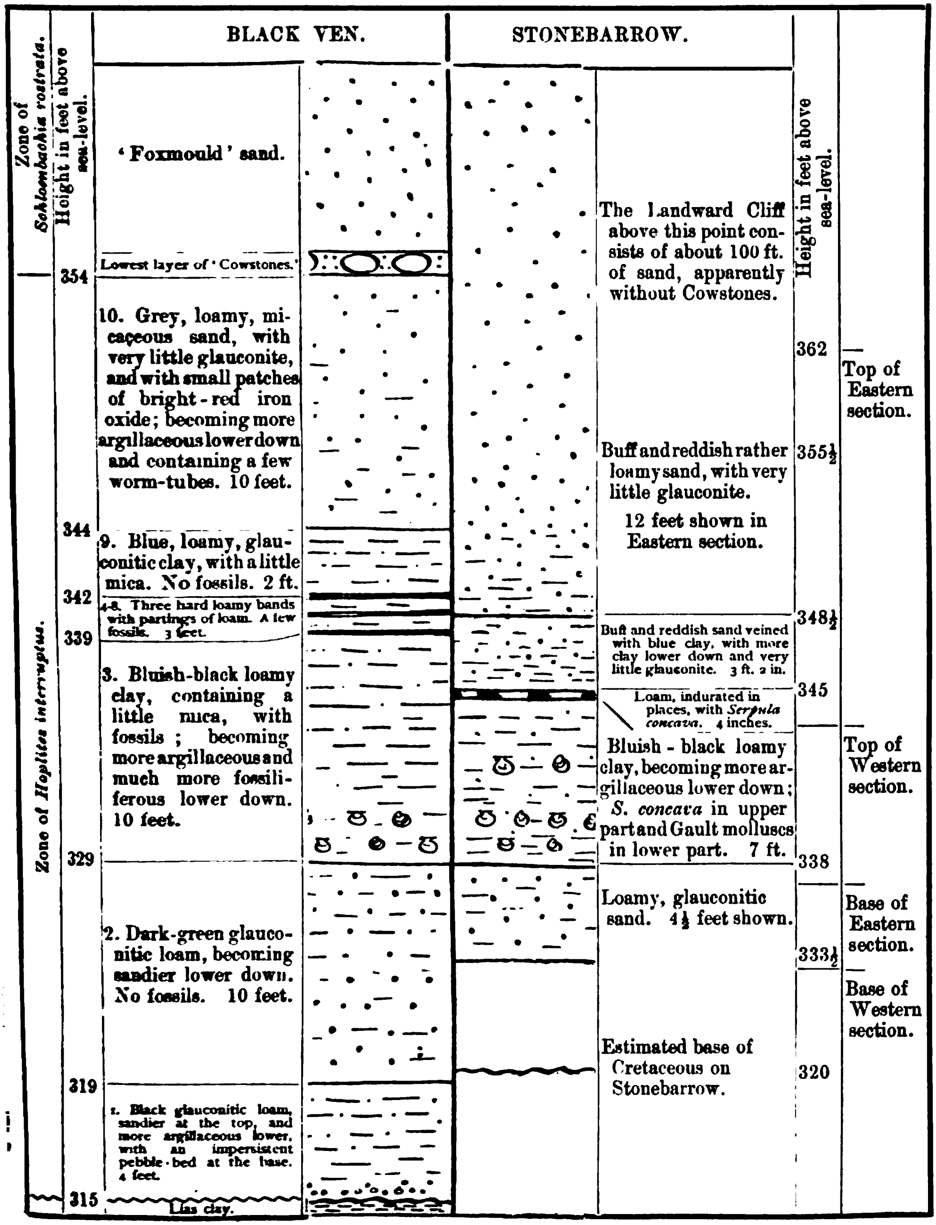
II. *The Western Gault Section.*

The western section is about 10 feet in extent. It is terminated above by a capping of fallen Greensand forming a small grass-covered flat on the general slope of the landward cliff. Two beds are to be recognized (see Fig. 2); the upper 7 feet are composed of bluish-black loamy clay containing Gault fossils of the same kinds as those found in Bed 3 on Black Ven, more being found at the bottom than at the top. This gives way below to a non-fossiliferous loamy, glauconitic sand, which is very soon hidden by talus. No alteration was observed on following it down for a foot or so by digging through the talus. The talus slope ends in the swampy ground already mentioned, which is nearly level with the footpath. The 300-feet contour-line on the 6-inch Ordnance map comes very close to the footpath; and since the descent here is very slight, cannot be more than 15 feet below it. Allowing about 20 feet for the talus slope and the swamp between this and the footpath, the base of the section would be at the height of about 334 feet, and the base of Bed 3 with the Gault fossils 338 feet.

III. *The Bluff between the Sections.*

The little bluff between the eastern and western sections is composed of bluish-black loam hidden under a wet matting of sandy soil washed down from above and bound by algæ and other plants into a tough felt. If this is peeled off the loam can be examined; but the examination proved unsatisfactory owing to the dripping state of the bluff and the bog at the bottom. No fossils were found in it and its horizon was not determined.

Fig. 2.—Diagram of the Zone of *Hoplites interruptus* and the base of the Zone of *Schloenbachia rostrata* on Black Ven and on Stonebarrow, to show correlation.


Zone of *Schloenbachia rostrata.*
Zone of *Hoplites interruptus.*
Height in feet above sea-level.
BLACK VEN.
STONEBARROW.
Height in feet above sea-level.
'Foxmould' sand.
Lowest layer of 'Cowstones.'
354
10. Grey, loamy, micaceous sand, with very little glauconite, and with small patches of bright-red iron oxide; becoming more argillaceous lower down and containing a few worm-tubes. 10 feet.
344
9. Blue, loamy, glauconitic clay, with a little mica. No fossils. 2 ft.
342
4-8. Three hard loamy bands with partings of loam. A few fossils. 3 feet.
339
3. Bluish-black loamy clay, containing a little mica, with fossils; becoming more argillaceous and much more fossiliferous lower down. 10 feet.
329
2. Dark-green glauconitic loam, becoming sandier lower down. No fossils. 10 feet.
319
1. Black glauconitic loam, sandier at the top, and more argillaceous lower, with an impersistent pebble-bed at the base. 4 feet.
315
Lias clay.
The Landward Cliff above this point consists of about 100 ft. of sand, apparently without Cowstones.
362
Top of Eastern section.
Buff and reddish rather loamy sand, with very little glauconite.
12 feet shown in Eastern section.
355½
348½
Buff and reddish sand veined with blue clay, with more clay lower down and very little glauconite. 3 ft. 2 in.
345
Loam, indurated in places, with *Serpula concava.* 4 inches.
Bluish-black loamy clay, becoming more argillaceous lower down; *S. concava* in upper part and Gault molluscs in lower part. 7 ft.
Top of Western section.
338
Loamy, glauconitic sand. 4½ feet shown.
Base of Eastern section.
333½
Base of Western section.
Estimated base of Cretaceous on Stonebarrow.
320

IV. *The Eastern Gault Section.*

On the eastern side of the bluff another section is seen in the Gault, which passes upwards into Foxmould. At the base occurs bluish-black loam with Gault fossils, and a little digging through the talus below exposes a junction with glauconitic loamy sand. These are obviously the two beds exposed in the western section. The blue loam becomes sandier on being traced upwards, and the fossils become scarcer, except that many *Serpula concava*, Sowerby, occur in the higher part. About 7 feet from the bottom of the section (see Fig. 2) an impersistent band of hardened loam containing *S. concava*, Sowerby, is found; above which the beds become quite sandy, with blue or grey argillaceous veins, for about 4 feet, and then pass into typical Foxmould sand.

In the right-hand half of Fig. 2 the two sections are represented combined in a diagram. The respective tops and bases of the two sections are marked on the right-hand margin.

The fossils recognised from the blue loam besides *S. concava*, Sowerby, were *Inoceramus concentricus*, Parkinson, *Lima gaultina*, Woods,[1] *Pecten* (*Syncyclonema*) *orbicularis*, Sowerby, *Pinna Robinaldina*, d'Orbigny,[2] *Grammatoceras* [*Arca*] *carinatus* (Sow.), *Pholadomya* sp., and *Corbula* sp.

V. *Comparison with the Corresponding Beds on Black Ven and on Golden Cap.* (Figs. 2 and 3.)

On the left-hand side of Fig. 2 is a diagram of the Gault beds on Black Ven, combining the two sections described in the GEOLOGICAL MAGAZINE for 1904.[3] Beds 2 and 3 of that section exactly correspond with the two lowest beds exposed on Stonebarrow, and since the fossil contents at the base of the higher beds are the same in each case it follows that they are on the same stratigraphical horizon. Now on Golden Cap, which lies two miles to the east of Stonebarrow (Black Ven is a mile and a third to the west of that cliff), the only account of the Gault is that by Jukes-Browne in the Survey Memoir.[4] In the section here described the same bed is distinguishable, consisting of dark loam with Gault fossils at the base, resting on a glauconitic sand. There is thus a stratigraphical datum-line on all three cliffs from which attempts at correlation of all the beds can be started.

On Black Ven, at about 25 feet above the Gault fossils, appears the lowest layer of Cowstones. And this has been taken as the base of the zone of *Schloenbachia rostrata*. But on Stonebarrow no Cowstones have been recorded. The landward cliff above the sections described is a steep slope of Foxmould sands capped by broken remains of the Chert-beds and of higher Cretaceous horizons. Here and there a section is shown, but the whole surface is much disturbed by fallen material and innumerable rabbit-burrows. Were Cowstones present they should not be hard to find, for owing to their hardness they stand out imminent from the section on Black Ven, and lie fallen in numbers in the boggy land beneath.

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[1] Hitherto recorded from the Gault of this district as *Lima parallela*. See Woods, "Cretaceous Lamellibranchs," vol. ii (1904), pp. 31 and 32: Mon. Pal. Soc.

[2] Hitherto recorded from the Gault of this district as *Pinna tetragona* or *P. subtetragona*. See Woods, loc. cit., 1906, p. 98.

[3] W. D. Lang, loc. cit.: GEOL. MAG., 1904, pp. 125 and 130.

[4] A. J. Jukes-Browne, "Gault and Upper Greensand of England," 1900, pp. 184 and 185: Mem. Geol. Surv.

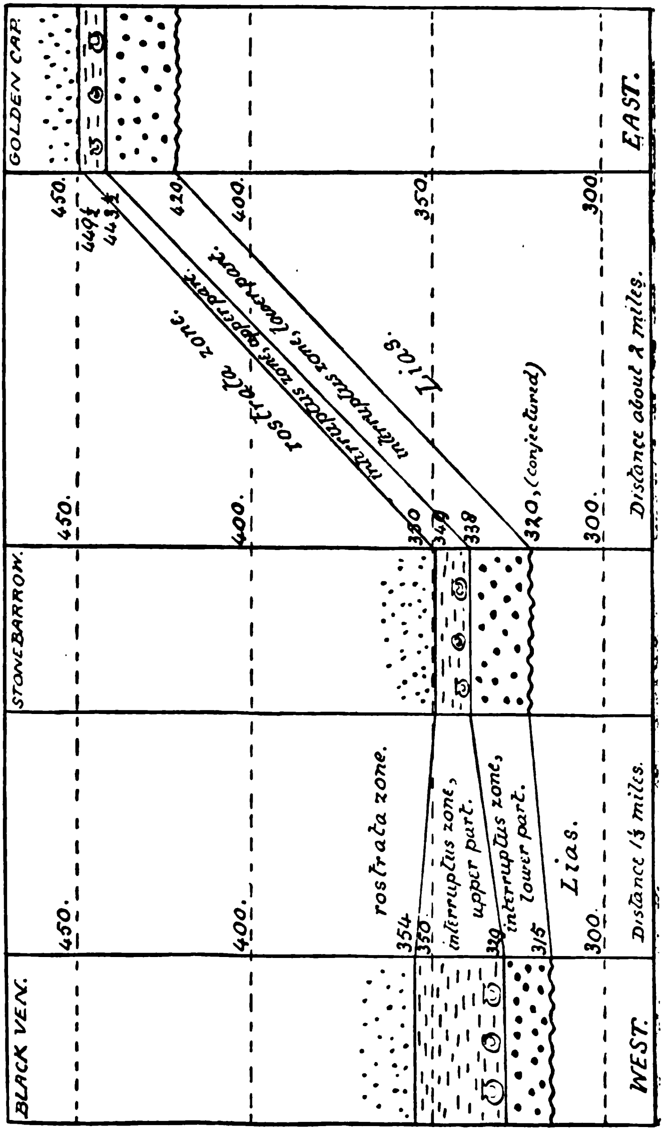

FIG. 3.—Diagram to show the variations in the thickness of the upper and lower parts of the zone of *Hoplites interruptus* on Black Ven, Stonebarrow, and Golden Cup.

The numbers in the diagram represent the approximate number of feet above sea-level.

In the absence of Cowstones it is impossible to draw the lithological limit between the zones of *Hoplites interruptus* and of *Schloenbachia rostrata* that is recognized on Black Ven. In the absence of fossils the true limit cannot be determined. If the point at which typical Foxmould sand begins is taken as the lower limit of the *rostrata* zone, it is obvious (see Fig. 2) that the *interruptus* zone is thinner on Stonebarrow than on Black Ven. Again, on Golden Cap, Jukes-Browne describes some 100 feet of sand (and no Cowstones are mentioned) resting directly on the Gault fossil bed, which is only 6 feet thick. That is, if lithological characters are taken into consideration in the absence of fossil evidence, the *interruptus* zone *above* Bed 3 has thinned from 25 feet on Black Ven to 11 feet on Stonebarrow and 6 feet on Golden Cap.

If fossils occurred it might be found that the zone had not thinned from west to east, but only become more sandy. But the evidence of the hard bands (Beds 4, 6, and 8) on Black Ven is against this supposition. For it looks as if the 4 inches of loam, indurated in places, containing *Serpula concava*, Sowerby, on Stonebarrow, was the equivalent of these hard bands on Black Ven. In that case Bed 3 on Stonebarrow would be 7 feet thick, against 10 feet on Black Ven; thus showing a thinning of the upper part of the zone eastwards.

The lower part of the zone remains to be considered. On Black Ven, beneath Bed 3, there are about 14 feet of loamy sand before the junction with the Lias is seen. On Stonebarrow the junction has not been found, and only a foot or two of loamy glauconitic sand is shown beneath Bed 3. On Golden Cap about 24 feet, chiefly of sands, are exposed beneath Bed 3, according to the interpretation here given to Jukes-Browne's section. It is probable, then, that the *interruptus* zone below Bed 3 thins from east to west, in the contrary direction to the upper part of the zone. Assuming that this thinning is regular, and taking two miles as the distance between the Golden Cap and Stonebarrow sections, and one and a third miles as that between the Stonebarrow and Black Ven sections, the thickness on Stonebarrow below Bed 3 would be 18 feet. This would make the base of the Cretaceous on Stonebarrow 320 feet above sea-level.

VI. *Summary and Conclusions.*

The chief results arrived at in this paper may be summarized as follows:—

1. The *Hoplites interruptus* zone is exposed in two small sections on Stonebarrow cliff, but the junction with the Lias has not been found.
2. A fossil bed containing the *interruptus* zone fauna occurs here, westwards on Black Ven and eastwards on Golden Cap, thus giving a stratigraphical datum-line.
3. That part of the zone above this fossil bed either becomes more sandy when traced from west to east, or, more probably, begins to thin out.
4. That part of the zone below this fossil bed thickens from west to east.
5. No Cowstones appear on Stonebarrow, nor have they been recorded from Golden Cap.

IV.—TITANIFEROUS VOLCANIC ROCKS.

By T. CROOK, A.R.C.Sc.I., F.G.S.

IN a paper read recently at a meeting of the Geological Society, Dr. Washington proposes to treat certain basalts of the Western Mediterranean basin as constituting "a hitherto unrecognised petrographic province, or comagmatic region, one of the most salient characters of which is the presence of salfemanes (basalts) that contain remarkably high amounts of titanium."[1]

He records the results of fourteen analyses. Of the specimens analysed, four are from Catalonia in Eastern Spain, four from Sardinia, and six from the two small islands of Pantelleria and Linosa. The results show a silica percentage varying from 44 to 52, alumina from 12 to 16, magnesia from 4·4 to 10·8. The titanium dioxide varies from 2·64 to 6·88 per cent. in the fourteen analyses given, with an average of 4·3 per cent. It should be pointed out that two of Dr. Washington's Pantelleria specimens were not collected by himself, and the specimen having the maximum content of titanium dioxide (6·88 per cent.) was bought from a mineral dealer. Phosphorus pentoxide is also abundant, but here again the maximum value (2·14 per cent.), which is in the mineral dealer's specimen, somewhat overshadows the rest. With regard to the figures for titanium dioxide, the Catalonia specimens show an average percentage of 4·33, those of Sardinia 3·26, Linosa 3·70, and Pantelleria 5·73. These figures, as far as they go, indicate a somewhat irregular distribution of titanium, with excessive segregation in Pantelleria.

The only earlier worker recognised by Dr. Washington as having noted the highly titaniferous character of certain basalts in the Western Mediterranean area is Dr. Förstner, who, as recently as 1891, found over 5 per cent. of titanium dioxide in a Pantelleria basalt. He appears to be unaware of the much earlier work done by Cordier, a conspicuous member of that little band of French workers, with whose collective labours on the structure and mineral composition of volcanic rocks, the science of petrography may be said to begin.

Among a large number of contributions made by Cordier to mineralogy and geology, three dealing with volcanic rocks are of special petrographical interest and value. These are as follows:—

1. "Recherches sur différens produits volcaniques": Journal des Mines, vol. xxi, No. 124, 1807.
2. "De la manière d'être du Fer titané dans les roches volcaniques, et du rôle qu'y joue ce minéral": Journal des Mines, vol. xxiii, No. 133, 1808.
3. "Mémoire sur les substances minérales dites en masse, qui entrent dans la composition des roches volcaniques de tous les âges": Journal de Physique, vols. lxxxii and lxxxiii, 1816.

The last-mentioned contribution is familiar. It has been excellently summarized and appreciated by Professor Cole (see *Aids in Practical Geology*). The first two appear not to be so well known. Their interest and importance were, however, fully recognised by Haüy and other early mineralogists; but they find no place in the bibliography of Fouqué & Lévy's *Minéralogie Micrographique*, and they have not been adequately appreciated by modern writers on petrography.

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[1] Dr. H. S. Washington, "The Titaniferous Basalts of the Western Mediterranean: a preliminary notice": Quart. Journ. Geol. Soc., vol. lxiii (1907), No. 249.

Since these three memoirs constitute a 'suite,' and as each forms part of a definite scheme of work by Cordier on the subject of volcanic rocks, it seems desirable that memoirs 1 and 2 should be summarized, especially as their main purport has an important bearing on the petrographic work dealt with in Dr. Washington's preliminary notice.

Memoir No. 1.

This embodies the results of the examination of a large number of black magnetic sands, obtained from river beds, and lake and sea shores, in the vicinity of volcanoes. Cordier regarded the sands as the disintegration products of the volcanic rocks with which they were associated. They were noted as being sufficiently abundant on certain beaches to tempt people to use them as iron-ore. They were rarely pure (presumably as iron-ore), being usually mixed with grains of many other minerals, including felspar, mica, pyroxene, amphibole, melanite (grenat noir), and leucite (amphigène), while sometimes corundum, zircon, spinel, and sphene (titane siliceo-calcaire) were present.

The highly magnetic portion of the sand was separated from the rest by means of a bar magnet, and it was submitted to special examination, including chemical analysis. The portion thus withdrawn was described as being strongly magnetic, some of the grains exhibiting polarity. Their specific gravity varied from 4·59 to 4·89, and in nearly all their physical characters they differed from ordinary magnetite (fer oxydulé), with which, up to that time, they had been confused.

He showed by analysis that these black highly magnetic grains contained a variable but fairly high percentage of titanium, and gave the following analyses:—

	Niedermennich.	Teneriffe.	Puy.
Oxide of iron	79·0 ...	79·2 ...	82·0
Oxide of titanium ...	15·9 ...	14·8 ...	12·6
Oxide of manganese ...	2·6 ...	1·6 ...	4·5
Alumina	1·0 ...	0·8 ...	0·6
Chromic acid	— ...	— ...	traces

We need not here discuss the merit of these analyses, except to point out that, in their essential features, they may reasonably be regarded as being fairly correct. Perhaps the most interesting feature is that chromium sesquioxide was observed to occur in traces, and it is not unlikely that this occurred as an isomorphous intergrowth of chromium spinel with magnetite.

Cordier examined, altogether, 27 samples of sand from the volcanic rocks of ten different countries. His localities include Central France, Eastern Spain, the Rhine, Rome, Vesuvius, Etna, and St. Pierre (Martinique). In no case did he find titanium oxide to be absent from the highly magnetic constituent; the amount was variable, but did not exceed 16 per cent. He concluded that this mineral was the same in all cases; that it was a compound of iron and titanium oxides; and he gave it the name *fer titané*. We need not here concern ourselves with the misfortune that befel the use of Cordier's term. It is sufficient for us to note that his *fer titané* is the same thing as our modern titaniferous magnetite (*titanomagnétite* of Lacroix); while the *fer titané* of modern French is the mineral ilmenite.

Memoir No. 2.

Having examined the sands, Cordier proceeded to work on the volcanic rocks themselves, and here again he examined material from many different sources. He first attempted to isolate the titaniferous magnetite by crushing and magnetic separation; but he observed that a considerable amount was always left behind, which could not be withdrawn in this way.[1] For this reason, he resorted to the method of leaching the titaniferous magnetite from the crushed rock by means of hydrochloric acid.

A large number of basalts, ashes, and tuffs, from Puy-de-Dôme, Vesuvius, Etna, Teneriffe, Popayan (South America), and elsewhere, were examined in this way, and analysis showed a variation from 0·5 to 4 per cent. in their titanium oxide content.

Cordier expressed surprise that titanium should be so widely distributed in volcanic rocks, and added that the only specimens which were practically free from it were those of certain pumices and glassy lavas. He estimated that 95 per cent. of volcanic rocks contained titaniferous magnetite in considerable amount, the proportion varying from 2 to 18 per cent. Its partial extraction, even when fine-grained and imperceptible to the eye, could be accomplished easily by crushing and separation with a bar magnet. Volcanic rocks owed their magnetic character exclusively to this mineral, except when hæmatite was present, which was very rarely. Its abundance in these rocks fully explained its plentiful occurrence in the sands which were derived from them by disintegration.

It is unnecessary to refer to Cordier's third and well-known memoir of 1815, except to note that in it he continues to use the name *fer titané* for the highly magnetic constituents of volcanic rocks. He distinguished this mineral from ilmenite, stating that the latter consisted of a combination of titanium and iron oxides in somewhat equal proportions, whereas *fer titané* contained only about 15 per cent. of titanium oxide. He was also aware that ilmenite was far less magnetic than titaniferous magnetite, and that with proper care it remained behind when the latter was extracted by the magnet. He found only a small quantity of ilmenite, as such, in the volcanic rocks which he examined.

There are many points arising out of Cordier's results which it might be profitable to discuss, did space permit. One point is especially worthy of emphasis, and that is the importance, in this particular case, of the simple process of crushing and magnetic separation as a means of distinguishing titaniferous magnetite from ilmenite, when these occur in rocks. It has been commonly considered that if leucoxene is developed among the cleavage cracks the mineral must be ilmenite. But it should be remembered that titaniferous magnetite also yields leucoxene as an alteration product; and it may on this account be safely asserted, that much titaniferous magnetite has been described as ilmenite on evidence gathered from rock sections alone. This confusion can be readily avoided by following Cordier's method of partially crushing the rock. It is convenient to sift, wash away the powder, and dry the residual grains. From these, magnetite, if present, can be withdrawn by a small hand magnet, whereas the ilmenite remains behind. The magnetite thus withdrawn is somewhat readily soluble in strong hot hydrochloric acid, and if the magnetite is titaniferous this can be proved chemically by the violet colour reaction on reduction with metallic tin.[1] In view of the simplicity and effectiveness of this process, Dr. Washington should have no difficulty in determining whether the titanium of his rocks is present as titanite, ilmenite, augite, olivine, or titaniferous magnetite. The matter is still under investigation, but Dr. Washington informs us that "the available data indicate that a large proportion of it is present in titaniferous magnetite, with probably somewhat less in the augite." On this matter we may venture to predict that further work will prove practically all the titanium to be present as titaniferous magnetite (and ilmenite), as Cordier showed about a hundred years ago.

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[1] Cordier appears to have thought that this was due to the extreme fineness of some of the particles, and the difficulty of freeing them from the matrix. It is not unlikely, however, that some of the grains which thus resisted attraction were ilmenite.

Now that we have attempted to do justice to Cordier, let us proceed to examine certain features of Dr. Washington's preliminary notice which seem to call for criticism.

On page 76 (loc. cit.) we are told that "the pale green or colourless augites of Central Italy are markedly titaniferous," one of them carrying 2·85 per cent. of titanium dioxide. On looking up the account given by Dr. Washington in "The Roman Comagmatic Region" to which he refers us, we find that the titanium-dioxide content of this augite was determined in the following manner:—"The rock powder used for the chemical analysis of the rock was digested for some hours in warm dilute hydrochloric acid, to which a little hydrofluoric acid was added. The residue was washed out with dilute solution of sodium carbonate, and the process repeated, but without hydrofluoric acid, the final residue being, of course, washed perfectly free from all soluble salts. This process would naturally dissolve all the leucite, olivine, melilite, magnetite, apatite, and anorthite, which are the only other minerals present, and would have only a slight effect on the augite, removing the outer portions." Then follows an analysis which shows 2·85 per cent. of titanium dioxide.

The obvious defect of this procedure is, that ilmenite and rutile may easily have been present in the powder analysed. It is a fact that rutile and ilmenite both occur as intergrowths with magnetite, and it is not at all uncommon for titaniferous magnetite to leave a residue of rutile when crushed and leached with strong hot hydrochloric acid. Therefore, unless it can be proved that ilmenite and rutile were absent, Dr. Washington's analysis of the above-mentioned rock residue does not prove that the titanium dioxide was present as titaniferous augite.

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[1] The possible occurrence of coarse intergrowths of ilmenite should always be kept in mind, and any residue which may be obtained should be examined magnetically, microscopically, and chemically, as rutile may also possibly be present.

As regards the Linosa hornblende, which "yielded as much as 8·47 per cent. of titanium-dioxide," we need evidence that no inclusions of ilmenite, etc., were present in the crystal analysed. Indeed, some of the evidence so far adduced by various workers to support the view that titanium enters vitally and in any serious quantity into the composition of ordinary ferromagnesian minerals, is not at all convincing in its character.

Again, on page 73 (loc. cit.) Dr. Washington makes the following statement concerning the Western Mediterranean basalts and their titanium content: "Of the minor constituents, titanium-dioxide is the most notable. This constituent is present in every case in very large amounts: large, that is, for this substance, the average amount of which in igneous rocks is 1 per cent. or less. Indeed, the higher figures found in the table are unparalleled elsewhere, except in titaniferous ores."

Now considering the fact that titanium dioxide is more abundant in basic than in acid igneous rocks, we may reasonably contend that the Western Mediterranean basalts should be compared with other basalts, rather than with rocks in general, if we wish to understand the correct bearing of any peculiarity which they may exhibit with respect to their titanium content. While it may be true that igneous rocks in general do not average more than 1 per cent. of titanium dioxide, this statement is not true of the salfemane class, and it is still less true of certain yet more basic types.

In order to test this point fairly, let us take the analyses of the rocks of the salfemane class given in Dr. Washington's valuable compilation of rock analyses.[1] Of the 230 superior analyses of salfemanes there given, in which titanium dioxide was actually estimated, these rocks show a range from 0·03 to 6·18 per cent. of that oxide, with an average of about 1·67 per cent. Of these 230 salfemanes, 75 have more than 2 per cent. of titanium dioxide, 33 have over 3 per cent., while 16 have more than 4 per cent., and several have more than 5 per cent.

Further, Dr. Washington gives in his list of superior analyses, five taken from the results obtained by Grubenmann for the melilite-basalts of Baden. Of these five analyses, one is included in the salfemanes and four in the dofemanes; they range from 4·79 to 8·85 per cent. of titanium dioxide.

Instances could be multiplied to show the abundance of titanium in certain basic igneous rocks which are not 'titaniferous ores.' Indeed, the abundance of titaniferous ores themselves as segregations in igneous rocks is sufficient to make any one pause before giving assent to Dr. Washington's proposition, that the percentage of titanium dioxide in the rocks of any region should be made a fundamental feature in characterising a petrographic province. At any rate, his statement that "the higher figures found in the table are unparalleled elsewhere, except in titaniferous ores," seems not to be in accordance with facts.

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[1] "Chemical Analyses of Igneous Rocks": Professional Paper, No. 14, U.S. Geol. Survey, 1903.

Another feature of Dr. Washington's preliminary notice appears to make a somewhat heavy demand upon our credence. The analyses recorded, as already mentioned, are of specimens from only four localities, two of which are small adjacent islands, but the other localities are widely separated; and we are asked to regard these few analyses of certain widely separated rocks as indicative of a condition prevailing throughout that portion of the Western Mediterranean region which he has partially defined.

In this connection, one important fact already mentioned should be specially emphasised, and that is, that no mineral exhibits a more pronounced tendency to segregation than does titanic iron-ore. That such is the case has been abundantly proved. In some cases, whole mountains are practically built up of material which has been segregated in this way. Such segregated titanic ores are usually local, and their occurrence is significant as indicating that titanium dioxide has an irregular distribution in rock magmas, using the term magma in a broad regional sense. Even the method of sampling would appear to be an insufficient correction for such an irregular distribution, as the segregations are likely to be either too prominent or altogether beyond observation.

This brings us to the important question: What are the criteria of a comagmatic region? If such criteria are to be scientific rather than merely empirical, it would appear important that they should be based essentially on features of somewhat persistent and uniform development. In this respect, varying amounts of constituents such as alkalies may be admitted to a high place as criteria, for not only do they seriously affect the constitution and physical properties of essential minerals; they are also partly responsible for the production of a characteristic group of minerals of great importance, and they have a somewhat uniform distribution.

But the same claim can scarcely be urged for titanium dioxide, since it separates early, is liable to segregation, and does not vitally affect the chemical constitution and physical properties of any important group of the minerals according to which rocks are classified. It remains to be seen whether further work in the Western Mediterranean area will justify the use of titanium dioxide as the principal index of a special province. The evidence so far presented is far from being conclusive. It would appear that Dr. Washington has laid too much stress on the significance of the titanium content of the few rocks he has so far analysed, and it remains to be demonstrated whether even these are typical, for the area is a large one. Further, it is a well-known fact that the estimation of titanium is a matter of considerable difficulty, and even where it has not been altogether neglected the stated percentage is often untrustworthy, being in many cases probably much too low. This fact adds considerably to the necessity of exercising caution in arguing from a comparison with hitherto published analyses.

Again, we may call attention to the fact that Grubenmann found as much as 3 per cent. of chromium sesquioxide in the highly titaniferous-melilite basalts of Baden. It seems that this constituent has not been determined in the Western Mediterranean basalts, in spite of the fact that they also might be expected to contain chromium.

Chlorine, too, finds no place in the table of analyses, even among the undetermined constituents, although the norms for the fourteen specimens analysed exhibit an average of about 2 per cent. of apatite, and one norm shows the unusual amount of 5·04 per cent. of that mineral. Dr. Washington informs us that chlorine is present in some of the Linosa rocks, but its amount has not been estimated, and it is regarded as being derived from sea-water. One might have thought, however, that such quantities of apatite would have rendered it necessary to provide a place for chlorine (or fluorine) in stating the results of a first-rate analysis; and there are other reasons why the estimation of chlorine in such rocks should not be disregarded. In point of quantity, at any rate, it is likely to be of as much importance as nickel oxide, for which a place is provided.

On the whole, these Western Mediterranean basalts are very similar to one another, and such important chemical differences as they exhibit are abundantly manifest in their mineral composition. Indeed, their essential similarity is so striking that one is surprised to find these rocks described under names so various as Monchiquose, Camptonose, Limburgose, Andose, Akerose, and Andose-Camptonose. It may be necessary, as a matter of convenience, to give names to rocks, but such a multiplication of names is neither necessary nor useful. Such names only conceal the truth, and lead people to believe that the evidence at present available for rock classification is of a higher order of exactness than it really is. The plain fact of the matter is that, just as in biology the process of evolution to some extent defies the wisdom of the systematist, so in petrology the processes of differentiation and admixture confound his artifices. Dr. Evans has recently shown that the American system has not escaped from confusion.[1]

Such being the case, it is interesting to note the new turn that has been given to petrology by the study of the physico-chemical laws which underlie the process of differentiation. A fuller knowledge of these laws will probably emphasise the significance of the mineral composition of rocks as an index to chemical conditions. When these laws have been worked out, it is not unlikely that mineralogical methods (including chemical analysis as a subsidiary feature) will meet the full demand which a natural-history study of rock relationships makes upon them. Such an issue would be welcome, as it would simplify rather than complicate the problem of classification; at any rate, it would render unnecessary the unnatural system and unwieldy terminology which the Americans have introduced.

In conclusion, we may be excused for emphasising the fact that many defects attend an exclusively chemical and too narrow view of rock analysis. In this respect, it is pleasing to be able to call in Cordier's work as an illustration of a liberal mode of enquiry, for the modern petrographer stands to gain by a sympathetic consideration of the methods which he used. By way of example, we may again refer to Dr. Washington's work on "The Roman Comagmatic Region." He there states that zircon has not hitherto been recorded authentically as occurring in the rocks of this region. We are inclined to ask what efforts have been put forth to find it. Have the surface deposits, such as river sands, been carefully examined?

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[1] "The Quantitative Classification of Igneous Rocks": Science Progress, No. 2, 1906.

Experience indicates that an examination of the sands lying in the streams which flow over the Italian basalts would almost inevitably reveal the presence of zircon and other minerals of petrographical importance. In making this statement we merely echo a note emitted by Bellevue 107 years ago. It should be unnecessary to point out that the mere examination of a few rock slices, or the analysis of one gram of a crushed rock, is not a fair way of determining the presence or absence of zircon in the rocks of a region involving hundreds of cubic miles. Perhaps a few figures will make this point more striking.

We may safely assert that an amount of zircon equivalent to 0·01 per cent.[1] of a basalt would probably be overlooked in a chemical analysis of the crushed rock, and appears usually to be missed in rock sections. And yet a cubic metre of such a rock would carry about 300 grams of zircon, assuming the latter to be uniformly distributed, which it usually is. In other words, a cubic yard of such a rock would carry about ½ lb. of zircon, from which we infer that a cubic mile would carry well over a million tons of this mineral. Hence we see that hundreds of millions of tons of zircon may be disseminated through the igneous rocks of a petrographic province, although it would not be detected by the chemical methods now in vogue.[2] It thus seems reasonable to urge that, if we are to talk of comagmatic regions, we cannot remain satisfied with the results of analysis applied to such small quantities of crushed rock as will barely cover the bottom of a crucible.

Bellevue and Cordier exhibit for us a way out of these difficulties. The stream deposits of a region retain the heavy residues which have resulted from disintegration carried out through immense periods of time and on numberless tons of material. The petrographer has foolishly left the study of these deposits to the prospector. From such deposits a miner's panning operation clears out most of the quartz; a magnetic separation eliminates the ferromagnetic minerals, and when this is done it is very seldom indeed, if ever, that zircon is not left behind in considerable quantity, and is readily identified with the microscope. If the rocks themselves are to be examined, they may be crushed, and in imitation of Chrustschoff, a few hundred grams of the crushings may be manipulated by physical methods to secure a zircon residue.

Zircon is not alone in this respect as a mineral the importance of whose regional dissemination is liable to be overlooked, though it is perhaps the commonest instance. The extensive distribution of monazite in small crystals in granites and gneisses is also of some importance, especially now that the radio-activity of rocks is being so much discussed. Considerations such as these may have an important bearing on the study of petrographic provinces. The possibility of using such minerals as supplementary magmatic indicators has not yet been considered; but if ever the eruptive rocks of the earth's crust are mapped out in a series of provinces, it is possible that such indicators may be important. These views give strength to the old-fashioned belief that natural mineral assemblages are more important than artificial norms. It may be, indeed, that future work will confirm the American method of making chemical analyses and artificial norms the primary basis of classification; but it is more likely that the working out of natural mineral assemblages on a comprehensive scale, and the characterisation of peculiarities in the minerals themselves, will be the ultimate goal of systematic petrography.

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[1] Allowing for the inclusions of such zircons, this would correspond to not more than 0·005 per cent. of ZrO_2.

[2] For the estimation of zirconia, Dr. Washington recommends the use of one gram of the crushed rock. See "Manual of the Chemical Analysis of Rocks," 1904.

V.—THE FAUNA OF THE BOKKEVELD BEDS.

By F. R. COWPER REED, M.A., F.G.S.

IT is useful from time to time to take stock of our knowledge in connection with such a geological problem as that of the fauna of the Bokkeveld Beds, so that we may ascertain to what stage in the process of its elucidation we have arrived, and may note the direction in which the evidence is pointing. An indication of the principal gaps in our knowledge may also be obtained in this manner, and new suggestions as to the more promising lines of investigation. The conclusions arrived at from such a survey may be employed tentatively as working hypotheses, but it may be premature to base upon them confident generalisations. Approaching the question of the composition, relations, origin, and distribution of the Bokkeveld fauna in this spirit of caution and with the foregoing objects in view, we find firstly that a considerable advance has been made in our knowledge of it and allied faunas during the last few years. The researches of Ulrich, Kayser, Clarke, Katzer, Thomas, and others in South America have given us an immense amount of fresh information on the Devonian faunas of that continent, and the South African fossils themselves have been studied by Lake, Schwarz, and the author. Their general poor state of preservation is a matter of regret, but the increase in the material available has cleared away some of the difficulties met with by Salter and other previous workers. Much undoubtedly remains to be learnt from work in the field, and we may expect further yields of new species from different localities in the immense area still to be explored.

The references given at the end of this paper do not aim at being a complete list of all recent literature dealing with the subject of the Devonian faunas of South Africa and South America, for only those works are quoted which appear to the writer to be of special interest or importance in connection with the Bokkeveld fossils.

STRATIGRAPHY.

The stratigraphical relations and sequence of the beds comprised in the Bokkeveld Series have been carefully observed in many parts of the Cape, and the succession of the beds, where typically developed, has been recently given by Rogers (1), and may be concisely expressed as follows (in descending order):—

SHALES	500 ft.	These beds are not so well defined as the lower divisions, and they contain only badly preserved plant-remains.
FOURTH SANDSTONE	100 ft.	
SHALES	300 ft.	
THIRD SANDSTONE	100 ft.	
SHALES	about 350 ft.	Often micaceous, with thin interbedded quartzites and usually few fossils (*Lingula*, *Nuculites*, crinoid stems, a trilobite, *Conularia*, plant-remains).
SECOND SANDSTONE	400 ft.	Many shale beds. Few fossils; *Spirifer* occasionally abundant.
SHALES	100–300 ft.	Fossiliferous (especially starfish, but also many species occurring in lower shales).
FIRST SANDSTONE	150 ft.	Slightly calcareous, containing many fossils locally, especially *Spirifer* and *Leptocœlia*.
SHALES AND THIN SANDSTONES	about 300 ft.	Often containing nodules, and many fossils (*Phacops*, *Homalonotus*, *Leptocœlia*, *Spirifer*, *Chonetes*, *Orthothetes*, *Orthoceras*, *Bellerophon*, *Nuculites*, and Crinoids).

A definite sequence of fossil forms in the successive beds might reasonably be expected, but Schwarz (2, p. 347) has recently declared that in spite of long and determined efforts he has failed to recognise any zonal succession or assortment of species in the series. This is distinctly disappointing, as in the homotaxial Devonian of South America certain, though not very strongly marked, faunistic differences are noticeable. A more or less decided difference in the faunistic facies can, however, be observed in the Bokkeveld Series, which is connected with the lithological character of the rocks; thus the shales possess a different assemblage of fossils to the sandstones, but this difference is seemingly due to bionomical causes and to the nature of the environment as expressed in the sedimentation rather than to a chronological replacement of types and a succession of different faunas each of stratigraphical significance. Accordingly we find ourselves forced at the present time to regard the fauna of the entire Bokkeveld Series as composing a simple and stratigraphically indivisible whole, even the faunules being scarcely distinguished as yet, though future work may modify this conclusion.

It has, indeed, been observed that there are peculiarities in the horizontal distribution of some of the organisms; for instance, the genus *Homalonotus* predominates in the western and northern, the *Spirifers* in the central, and the ornate *Phacops* in the eastern outcrops, according to Schwarz (2). But to what these facts point is at present uncertain.

From the foregoing remarks it will be seen that in the present state of our knowledge we must include all the fossils from every locality and bed in the same list, and this principle is accordingly followed.

COMPOSITION OF THE FAUNA.

The various zoological groups of organisms are treated here separately in order to discuss conveniently the special characters of various members and of the general features of each group.

(*a*) *Trilobita.*

The trilobites include the following species, adopting Schwarz's (2, pp. 382–400) modifications of Lake's (3) list:—

Homalonotus agrestis, Schwarz.
H. colossus, Lake.
H. Herscheli, Murchison.
H. hippocampus, Schwarz.
H. horridus, Schwarz.
H. lex, Schwarz.
H. perarmatus, Frech.
H. quernus, Lake.
H. Herscheli, var. or sp. nov., Schwarz.
H. sp., Lake.
Phacops acacia, Schwarz.
Ph. (*Acaste* ?) *africanus*, Salter.
Ph. arbuteus, Lake.
Ph. (*Cryphæus*) *caffer*, Salter.
Ph. (*Cr.*) *callitris*, Schwarz.
Ph. (*Cr.*) *Ceres*, Schwarz.
Ph. cristagalli (Woodward).
Ph. (*Cr.*) *Gydowi*, Schwarz.
Ph. impressus, Lake.
Ph. ocellus, Lake.
Ph. pupillus, Lake.
Phacops ? sp., Lake.
Dalmanites lunatus, Lake.
D. sp., Lake.
Proetus malacus, Lake (? = *Pr. Ricardi*, Schenck).
Typhloniscus Baini, Salter.

By the foregoing list it will be observed that out of the 26 species of trilobites so far recorded, 22 (or 24 if we include *Dalmanites* in the genus *Phacops*) belong either to the genus *Homalonotus* or *Phacops*, using the latter name in a broad sense. The distinction of the various species and their precise number is a matter of some uncertainty, some of them having been founded on isolated pygidia and others on isolated head-shields, which in some cases at any rate probably belong to the same species. There is also a difference of opinion as to the specific union of some of the types, Schwarz splitting up Salter and Lake's *H. Herscheli* into four species, and ascribing Lake's type of *Ph. cristagalli* to a new species, *Ph. acacia*.

In the above list the subgeneric names and references of certain of the Phacopidæ are given according to Schwarz and Lake's usage. But it may be pointed out that neither of the terms *Acaste* nor *Cryphæus* can be applied to trilobites for reasons of priority (4) (5). With regard to the rightful inclusion of any of the South African species in either of the two groups or subgenera signified by these names, Salter, Lake, and Schwarz have generally been doubtful, though Lake (3, p. 211) says that *Ph. caffer* is a "true *Cryphæus*."

The group designated by the name *Cryphæus* (Green, 1837) was founded on the American species *Cr. Boothi*, Green, in which the axis of the pygidium has 10–14 rings and the lateral lobes 5 ribs produced into spines round the margin, and there is also a more or less developed median terminal spine in the variety *Cr. collitelus*, Green. Hall & Clarke (6, p. xxxiii) defined the subgenus *Cryphæus* (genus *Dalmanites*) as follows: "Genal angles produced into long, often laterally compressed, and narrow spines. Posterior thoracic segments produced and acute. Pygidium with five annulations and five pairs of marginal lobes or spines. Terminal lobe more or less developed." *Ph. caffer* has 10–11 rings on the axis of the pygidium and 5 ribs on each lateral lobe produced into spines. *Ph. ocellus* and *Ph. impressus* are probably also allied, though the pygidial axis in the former bears only 7 rings and in the latter only 8–9. In *Cr. Barrisi*, Hall, of the Hamilton Group there are only 6–8 rings on the axis, so that the small number in these two species is not quite exceptional.

Ph. callitris is said by Schwarz (2, p. 394) to agree in many particulars with *Ph. ocellus*. *Ph. Gydowi* is similar in many respects, and *Ph. Ceres* is undoubtedly allied. In all these species there is a marked tendency for the second pair of glabellar lateral furrows to be reduced and not to enter the axial furrows, resulting in a more or less complete fusion of the first and second lateral lobes of the glabella. The same feature is met with in *Acaste* (= *Phacopidella*), which is a Silurian group, comprising *Ph. Downingiæ*.

The genal angles are not produced into long spines, but where the head-shield is sufficiently known they seemed to have been angular (*Ph. impressus*), rounded (*Ph. ocellus*), or furnished with small laterally directed spines (*Ph. callitris*). Herein they differ markedly from typical *Cryphæus*, and seem to furnish an additional point of resemblance to *Acaste*. If a distinctive name for this group is required, the name *Metacryphæus* is suggested.

The remaining Phacopidæ from the Bokkeveld Beds seem to fall into another group which in many respects resembles that containing *Dalmanites anchiops*, Green, and was mistakenly referred by Hall and Clarke to McCoy's subgenus *Chasmops*, which has completely different characters (4, p. 10). The definition of the subgenus according to Hall & Clarke (6, p. xxxiii) was apparently drawn up from the type of *D. anchiops* of the Oriskany Sandstone and Upper Helderberg, and runs as follows: "Genal angles usually produced into spines. Frontal lobe of the glabella large, transverse, and not intersected by the facial sutures. Lateral lobes unequal, the first and second pairs being coalesced and the third pair nearly obsolete. Pygidium large, sometimes with a terminal spine." *D. anchiops*, Green (6, p. 59, pl. ix, figs. 1–6, 10, 12, 13; pl. x, figs. 1–14), has genal angles produced into stout long spines; there is a nuchal spine on the occipital ring; the first and second lateral lobes of the glabella have coalesced owing to the reduction of the second lateral furrows; the eyes are large and lunate and appressed to the first and second coalesced lobes; the pygidium has an axis with 9–14 rings and lateral lobes with 8–9 ribs, and it is produced into a more or less upturned tapering mucronate termination. In the South African *Ph. cristagalli*, *Ph. arbuteus*, and *Ph. acacia* we see several of these features. The first has precisely the same type of pygidium, but it has only seven lateral ribs, and these are tuberculated, and the axis, which consists of *eight* rings, carries a single row of median spines like the thorax. The head-shield is unknown. In *Ph. arbuteus* there is a slight reduction of the second lateral furrows, the neck-segment bears a strong median spine, and the pygidium has the typical mucronate shape, but only bears 8 rings on the axis and 5 ribs on the lateral lobes. The axis of the thorax bears a median spine on each segment, but they seem to be absent from the pygidium. In *Ph. acacia* the neck-segment bears a strong median spine, the genal angles are furnished with short spines, the third glabellar lateral furrows (as in *Ph. arbuteus*) are specially deep, the axis of the thoracic segments bears median spines as in the other two species. *Ph. pupillus*, only known by an incomplete head, has cranidial characters of precisely the same type.

With regard to *Ph. africanus*, which has been suggested to belong to *Acaste* (= *Phacopidella*, Reed), the head has exactly the same general characters as the foregoing species, i.e., a strong nuchal spine, a very deep third glabellar furrow, a median spine (probably, according to Lake) on each thoracic axial ring, and a pygidial axis produced beyond the margin bearing 9 rings, with 5 ribs on each lateral lobe. Schwarz (2, pp. 398–399) has indeed hinted that it may belong to the *cristagalli* group, and Salter believed that the genal angles were spined, thus increasing the resemblance. There does not therefore appear to be sufficient grounds for separating it from this group, and I would refer this whole set of species to a special subgroup of *D. anchiops* characterised (1) by fewer (typically 8) segments in the pygidium, only 5 pairs of ribs being present as a rule on the lateral lobes; (2) by the presence of median spines on the axis of thorax and pygidium; (3) by small, instead of stout and long, genal spines (in *D. anchiops*, var. *armatus*, Hall (6, p. 62, pl. ix, figs. 7–9), the genal spines are inconspicuous or obsolete); (4) by less pronounced coalescence of first and second lateral lobes of glabella. (Nom. prop. *Anchiopella*.) Clarke (8, p. 33) considered the Maecurú species described by him as *Dalmanites galea* as a representative of the genus *Acaste*, Salter, on the strength of the coalescence of the first and second lateral lobes of the glabella, rounded genal angles, and general characters of the head-shield on which the species was founded. In discussing its resemblance (8, p. 57) to *D. gonzaganus*, Clarke, from the same horizon in Parana, he alludes to its resemblance to *D. anchiops*, var. *sobrinus*, Hall, of the Schoharie grit.

The relations of several of the trilobites to South American forms have been pointed out by Lake and Schwarz, and in the light of recent knowledge the identical or allied species are as follows:—

(B. = Bolivia; Br. = Brazil; A. = Argentina.)

Phacops arbuteus	*Phacops* cf. *arbuteus*. B.
Ph. (*Cryphæus*) *caffer* ...	*Cr. giganteus*, Ulr. B. *Cr. paituna*, Clarke. Br., B. *Cr. convexus*, Ulr. B.
Ph. africanus	*Ph.* (*Acaste*) *devonicus*, Ulr. B. *Dalmanites galea*, Clarke. Br. *D. gonzaganus*, Clarke. Br.
Ph. Ceres	*Cr. giganteus*, Ulr. B.
Dalmanites sp.	*D. Clarkei*, Ulr. B. *D. maecurua*, Clarke. Br., B.
Homalonotus Herscheli ...	*H. Derbyi*, Clarke. Br.

The relations of the two South African groups of Phacopidæ to the North American *D. Boothi* and *D. anchiops* have been above discussed. Clarke (8, pp. 80, 98) has remarked that the cephalon of *D. galea* and *Ph. devonicus*, Ulrich (9, p. 21, t. i, figs. 14*a*, *b*, 15), have a Silurian type of Phacopid structure, and Lake also alludes to it, but except in the reduction of the second pair of glabellar furrows the resemblance is rather remote.

The affinities of the species of *Homalonotus* from South Africa with those of South or North America are not very marked, and Lake compares some of them to European species of Coblenzian age. According to Schwarz, all the Bokkeveld *Homalonoti* have a strong family likeness, and they do not seem allied closely to any of the five species from South America mentioned by Thomas (10), except to *H. Derbyi*, Clarke. The latter species, according to Katzer (15, p. 21), has its allies in the Silurian of North America. Haug (11) has recorded *H. Herscheli* from the central Sahara, but Schwarz (2, p. 387) says this fossil comes nearest to the South African *H. agrestis*, and that it reminds him more of *H. obtusus*, Sandberger, from the Upper Lower Devonian of the Rhine. A species of *Cryphæus* has also been recognised by Haug from the same locality.

No true member of *Phacops*, sens. str., is known to be present in the Bokkeveld Beds, but in South America a fossil from Bolivia was long ago attributed to *Ph. latifrons* by Forbes (29), while Ulrich (9) has described from the same region a peculiar type, *Ph. Dagincourti*, with submarginal denticulations to the head-shield. A form compared with *Ph. rana*, Green, has also been figured by Kayser from Argentina (20, p. 284). The South African *Typhloniscus Baini* is unique, and its true relations are still somewhat problematical. *Proetus malacus* is not very satisfactorily known.

(*b*) *Brachiopoda.*

The Brachiopoda are represented by the following large number of species :—

Lingula aff. *densa*, Hall.
L. sp., Reed.
Orbiculoidea Baini (Morr. & Sh.).
Stropheodonta cf. *concinna* (Morr. & Sh.).
Strophonella sp., Reed.
Orthothetes Sulivani (Morr. & Sh.).
Chonetes falklandicus, Morr. & Sh.
Ch. cf. *coronatus*, Conr.
Ch. cf. *Arcei*, Ulrich.
Ch. aff. *setiger*, Hall.
Orthis sp. (?), Reed.
Rhynchonella (*Camarotœchia* ?) sp., Reed.
Rensselæria relicta, Schwarz (? = *R.* sp. *α*, Reed).
R. cf. *confluentina*, Fuchs.
R. hottentot, Schwarz (? *Rhynchospira*).
R. sp. *β*, Reed.
R. ? sp., Reed.
Trigeria aff. *Gaudryi*, Oehl.
Tr. (? *Rhynchospira*) *simplex*, Schwarz.
Rhynchospira ? cf. *Silveti*, Ulrich.
Cryptonella Baini, Sharpe.
Cr. ? sp., Reed (? = *Oriskania navicella*, Hall & Cl.).
Spirifer antarcticus, Morr. & Sh. (= *Sp. Orbignyi*, Reed = *Sp. antarcticus* + *Sp. Orbignyi*, Schwarz).
Sp. Ceres, Reed.
Sp. cf. *pedroanus*, Hartt (included in *Sp. antarcticus* by Schwarz).
Sp. sp. *α*, Reed (included in *Sp. antarcticus* by Schwarz).
Sp. sp. *β*, Reed.
Ambocœlia umbonata (Conr.).
Retzia cf. *Adrieni*, De Vern.
Leptocœlia flabellites, Conr.
Scaphiocœlia ? *africana*, Reed.
Ptychospira variegata, Reed.
Vitulina pustulosa, Hall.
? *Tropidoleptus carinatus* (Conr.).

Some difference of opinion with regard to the generic position and specific relations of the fossils referred to the genera *Trigeria*, *Rhynchospira*, and *Rensselæria* exists (2) (5), but until better preserved specimens are available it does not seem possible to settle the vexed questions. In the case of the Spiriferidæ the separation of some of the species is a matter of opinion, but Mr. J. Thomas (10, p. 261) and Mr. E. T. Newton (12, p. 252) have recently supported my contention as to the undesirability of separating *Sp. antarcticus* and *Sp. Orbignyi*, and my attention has also been called to a previous paper by Scupin (13) on these very species. Both *Sp. antarcticus* and *Sp. Orbignyi* of the Falkland Islands are held by him to represent only one variety of Hall's species *Sp. arrectus*, and for this variety the name *antarcticus* is retained. To this variety belongs also the Bolivian species *Sp. Chuquisaca*, Ulrich. Some of the South African specimens figured by Sharpe (14, pl. xxvi, figs. 1, 3, excl. cet.) under the names *Sp. antarcticus* and *Sp. Orbignyi* are referred to the typical form of *Sp. arrectus*. The species *Sp. Hawkinsi* (Morr. & Sh.) from the Falkland Islands is chosen to designate another variety of *Sp. arrectus*, to which also *Sp. Vogeli*, V. Ammon, from Brazil, is assigned. According to Scupin, therefore, the South African, Brazilian, Bolivian, Falkland Islands, and, we may add, Argentine forms known under the diverse names of *Sp. antarcticus*, *Orbignyi*, *Chuquisaca*, and *Vogeli* may all be included in the one North American species *Sp. arrectus*, which is closely allied to the European *Sp. primævus*.

In the Devonian beds of Tassili in the Sahara, Haug (11) records *Spirifer* cf. *Rousseaui*, M. Rouault, which, as he states, belongs to the same group.

The occurrence of *Tropidoleptus carinatus* in the Bokkeveld Beds, though mentioned by Ulrich (9), is somewhat doubtful, no other palæontologist having observed it.

(*To be continued in our next number.*)

VI.—THE CHEMICAL COMPOSITION OF IGNEOUS ROCKS: A NEW METHOD OF OBTAINING IT.

By ARTHUR WADE, F.G.S.

ANY science which cannot express its conclusions by means of number must still be regarded as in its infancy. Such an expression is the only test of precision and accuracy of thought on the part of its workers, and such important characters only develop, as in the human mind, when the romance and rashness of youth have given place to the more cautious and matter-of-fact features of maturity. It is therefore a sign of healthy development when those engaged in the study of petrology begin to turn their attention towards careful numerical calculation as a basis of classification.

This has been done in a very elaborate fashion by the authors of the new "Quantitative Classification of the Igneous Rocks,"[1] and whilst reserving our opinion with regard to the ultimate value of this new American scheme, there is no doubt that it emphasises the importance of certain features which we in Britain are apt to hold too lightly. The most important of these is the absolutely essential nature of obtaining some fairly accurate idea of the chemical composition of a rock before proceeding to assign to it a position in any rock-group or family. The making of a complete chemical analysis of a rock is a somewhat tedious and delicate process requiring much technical skill, and few petrologists find themselves able to undertake such work, though the need for it is becoming more and more apparent. A valuable alternative, however, remains. Many remarkably accurate and useful results have been obtained by the application of the 'Linear Traversing Method'[1] of Rosiwal. By this method the percentage mineral composition of the rock is obtained. By multiplying each quantity by its density and making use of the known chemical composition of the minerals we get a fairly accurate statement of the quantitative chemical composition of the rock.

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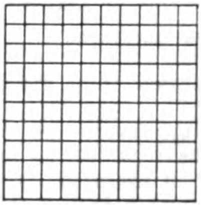
[1] Cross, Iddings, Pirsson, & Washington: "Quantitative Classification of the Igneous Rocks"; Chicago, 1903.

I wish, however, to suggest a method which will be found, I hope, more simple, and with a little care equally effective. Instead of the ordinary eyepiece with single cross wires one should be obtained fitted so as to give a square field. This field should be crossed by wires dividing each side of the square into ten equal parts, and the whole area therefore into 100 equal divisions. In making an examination of any rock section the percentage mineral composition of the part of the slide under examination is easily found by simply counting the squares occupied by the several mineral species present. By taking a number of observations in different parts of the same slide and obtaining an average a fairly close approximation to the actual chemical composition of the rock from which the section is cut can be obtained by a skilful observer. This average would, of course, become more closely approximate by considering more than one section cut from the same specimen.



Field of Eyepiece showing the arrangement of crosswires.

Thus by means of this simple arrangement a student should be expected, not merely to identify the mineral constituents present in a rock section, and so obtain a general idea of its relationships, but to express his conclusions with regard to both mineral constitution and chemical composition by means of number. This would constitute a real step in advance in the study of petrology as carried on at present in this country, and would probably lay the foundations for a more satisfactory system of classifying the igneous rocks than the somewhat hazy one now in vogue.

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[1] See Rosiwal, Verbuch. Wien Geol. Reichs. Anst., vol. xxxii (1898), or "Quant. Classif." above, p. 204.

NOTICES OF MEMOIRS.

ARRHENIUS' THEORY OF THE PHYSICAL CAUSES OF VULCANICITY.[1] By R. H. RASTALL, M.A., F.G.S., Fellow of Christ's College, Cambridge.

[*Note*.—As this paper in its original form is very inaccessible to most readers, its importance has perhaps scarcely been appreciated in this country; the following short abstract has been made at the suggestion of Professor Bonney, in the hope that it may be of use to students of geology and others.]

(1) *The Condition of the Earth's Interior.*

THE conclusions of astronomers and physicists are irreconcilable with the hypothesis of the existence of any considerable amount of matter in the liquid form in the interior of the earth. This idea rests for the most part on a misconception of the physical properties of matter under the enormously high pressures which prevail at great depths. Nearly all known substances, with the notable exception of water, contract in volume on solidifying, and in consequence their melting-point is raised by pressure. The investigations, however, of Damien, Barus, and especially of Tammann, have shown that at very high pressures this relation no longer holds. Tammann found that the maximum melting-point of dimethylethyl-carbinol is reached under a pressure of 4,750 atmospheres, and at higher pressures the melting-point falls; it seems probable that other substances would behave in a similar manner under similar conditions. Hence it appears that at great depths the constituents of the globe must be in reality in the gaseous state, since pressure cannot keep them solid or even liquid by raising the melting-point. But the physical properties of gases under such conditions must be very unlike those with which we are acquainted. The true difference between a liquid, a solid, and a gas lies in the rate at which they respectively undergo deformation under stress. The necessary physical constants have been determined by Reinganum in the case of isopentane at the highest attainable pressures, and from these it is calculated by extrapolation that at a depth of 1,000 kilometres the compressibility of gaseous isopentane must be about equal to that of steel. The temperature in this case must be far above the critical point, and the material is actually gaseous, though its physical properties resemble those which are commonly associated with the idea of a solid. Rock-magma under similar conditions would undoubtedly possess a still lower compressibility.

Assuming the temperature-gradient to be 3° C. per 100 metres, the melting-point of most rocks, about 1,200° C. is attained at a depth of about 40 kilometres, while below this lies a liquid zone. At a still greater depth the critical point is passed, and the magma is in the gaseous state, though intensely rigid. From the high density of the earth as a whole, compared with that of the visible portion, it appears that the inner nucleus consists of some metallic substance, probably iron. From the known data it is easy to calculate that about 80 per cent. of the earth's diameter must be occupied by gaseous iron, 15 per cent. by gaseous rock-magma, and 4 per cent. by liquid magma; the rest, less than 1 per cent., forms the solid crust.

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[1] Arrhenius, "Zur Physik des Vulcanismus": Geologiska Foreningens i Stockholm Forhandlingar, Band xxii (1900), p. 395.

These theoretical conclusions are supported by the results of earthquake observations. The seismograph record of a distant earthquake shock shows a clear division into two phases, viz. preliminary tremors and the principal shock. The explanation of this fact is, as Milne pointed out, that the principal shock is propagated along the crust, while the preliminary tremors travel along the chord of the arc. Since these latter are much diminished in intensity, it follows that the internal friction of the material of the inner parts of the globe must be very great, which is in harmony with the assumption of a liquid or gaseous condition rather than with the solid state.

(2) *Volcanic Phenomena.*

It is unnecessary to prove in detail that in all volcanic eruptions great quantities of gases, and in particular water-vapour, are given off, and the pressure of this gaseous water at a temperature above its critical point is undoubtedly the chief motive-power of the eruption. Each explosion relieves the pressure for the time being, but the frequent recurrence of eruptions from the same vent shows that further supplies of water must by some means reach the magma, and this in spite of enormous counter-pressure. The ocean-floor, with its capillaries, may be supposed to act as a semi-permeable membrane, through which the water penetrates by osmotic pressure. Assuming the density of the magma to be about 2·7, it can easily be calculated that in order to overcome the pressure of the overlying column of rock the osmotic pressure at a depth of 10,000 metres must be about 1,700 atmospheres, and this in itself is not inconceivable. But since the dissolved constituents of the magma show this high osmotic pressure they must enter into chemical combination with the water.

According to Thomsen's measurements water at the ordinary temperature is a very weak acid, about 100 times weaker than silicic acid, but on raising the temperature these relations no longer hold. While silicic acid, which has a heat of neutralization equal to those of nitric and hydrochloric acids, does not change its strength notably, the case is very different with water. From the data with regard to the behaviour of water between 0° and 50°, it can be calculated by a well-known extrapolation formula that at 300° water and silicic acid are equally strong, at 1,000° water is 80 times, and at 2,000° 300 times as strong as silicic acid. It is true that this result is obtained purely by extrapolation, but it is of no practical importance whether water is 300 times or only 100 times as strong as silicic acid, so long as it is distinctly the stronger, and this the calculation shows with certainty.

(3) *The Chemical and Physical Action of Water on the Magma.*

Let us now suppose water to be in contact through a semi-permeable membrane (the sea-floor), with a magma between 1,000° and 2,000° C. Water penetrates into the magma by osmosis and acts as a relatively powerful acid on the silicates, by which means silicic acid and bases are set free. These combine with more magma, and form acid and basic silicates. Further addition of water then sets up new decompositions, but some water always remains free in the magma, although on account of its relatively small amount it has a very low vapour-pressure, in accordance with Raoult's law. The process can go on till a great part of the magma is decomposed. The magma must also increase in volume on taking up water, by very nearly the volume of the water absorbed.

The swollen magma, which has also become more fluid, exerts pressure on all sides, and the column rises still further in the vent which is in connection with the magma-basin. On rising, the magma is cooled in the narrow vent, the water continuously becomes a weaker acid, and is displaced by silicic acid from the hydrates; the pressure of the aqueous vapour rises in spite of the fall of temperature, and if the watery layer comes near enough to the surface, and therefore under sufficiently low external pressure, steam explosions will occur.

According to this theory a volcano acts very like a geyser. As the water rises in a geyser, so it does in a volcano, though in this case it is mostly in chemical combination with the magma. At great depths, and therefore under high pressures, the water in the geyser and the watery magma in the volcanic vent are under higher pressures than those corresponding to the maximum tension of the water-vapour, and no explosion is possible. When a magma enters the vent of the volcano and rises in it, it at last reaches a point where, on account of separation of water from the magma through cooling, the pressure of the water-vapour exceeds the external pressure. Then an explosion occurs, blowing a passage through the overlying layers, and thus leading to renewed explosions by relief of pressure. This goes on till so much water has separated from the magma that the remainder cannot overcome the external pressure. Then ensues a period of temporary quiescence, with slow loss of water-vapour by diffusion, until after a sufficient lapse of time so much water penetrates into the magma-basin that the process begins anew.

REVIEWS.

I.—New Geological Survey Maps and Memoirs.

1. The Geology of Falmouth and Truro and of the Mining District of Camborne and Redruth. By J. B. Hill, R.N., and D. A. MacAlister, A.R.S.M., F.G.S.; with Petrological Notes by J. S. Flett, M.B., D.Sc. 8vo, cloth; pp. x and 336, 24 plates. Pages 1–112 form Part I, Geology; pp. 113–314 form Part II, Mining; pp. 315–324 are Bibliography; and pp. 325–335, Index. Price 7*s.* 6*d.*; in explanation of colour-printed map, Sheet 352, 1*s.* 6*d.* (E. Stanford: London, 1906.)
2. The Geology of the Country near Newquay. By Clement Reid, F.R.S., F.L.S., F.G.S., and J. B. Scrivenor, M.A., F.G.S.; with contributions by J. S. Flett, M.A., D.Sc., W. Pollard, M.A.,

D.Sc., and D. A. MacAlister, A.R.S.M. 1906, price 3*s.*, 9½ inches by 6 inches; pp. iv + 131, with 6 plates (photographic process) and 23 figures. Pages 1–90 are devoted to Geology; pp. 91–119 form Appendix I, Mines; pp. 120–122 form Appendix II, Bibliography; pp. 123–131, Index. In explanation of Sheet 346.

AMONG the recent publications of the Geological Survey are Sheets 346 (Newquay) and 352 (Falmouth) of the New Series of one inch to one mile ($\frac{1}{63360}$) colour-printed maps of England and Wales, both dated 1906, price 1*s.* 6*d.* each. The area comprised in Sheet 352 extends from Gerrans Bay on the east to (and inclusive of) Camborne on the west, from Porthtowan on the north to Falmouth Bay on the south. The formations represented are in ascending order. I. The Mylor Series; in the south-west of the map it occupies almost two-thirds of the area represented, if we disregard the great granite masses intrusive in it. The Mylor Series encloses the various greenstones, the greater portion of the elvan dykes, and, in conjunction with the granites, almost the whole of the mineral lodes. II. The Falmouth Series occurs in several minor and three considerable areas—(1) between Porthtowan and Reskajeage Downs; (2) between St. Day and Truro; (3) on the coast of Falmouth Bay. III. The Porthscatho Series occupies a large area in the east and extends in a mile-wide band along the north of the area. IV. The Veryan Series is restricted on the map to a triangular tract of about half a square mile on Gerrans Bay.

In the legend of the map the preceding formations are merely bracketed together as Lower Palæozoic, but in the corresponding memoir they, together with the Lower Devonian Grampound Beds, which form a mile-wide strip along the northern margin of the map area, are grouped together as Killas, viz. slate deposits.

A deposit of quartz gravel, occupying an area less than half a mile in length and about a quarter of a mile in breadth, occurs near Polcrebo, in the heart of the granite district, and is mapped as Pliocene. "Raised Beaches, Head, Alluvium, and Blown Sand" complete the list of sedimentary formations. Perhaps the most interesting feature of the map is the rudely circular Carnmenellis boss of muscovite-biotite granite, about 9 miles in diameter, which occupies the south-west of the map. Like the two smaller adjacent granite masses of Carn Brea and Carn Marth, it is surrounded by an aureole of metamorphism. Intrusions of greenstone (largely referable to the group of epidiorites), elvan, or quartz-porphyry dykes, the latter generally trending about east-north-east (like the mineral lodes), and mica traps or minettes are also shown. The numerous mineral lodes of the area are almost entirely confined to the western district, and are mainly restricted to the neighbourhood of the granite, but continue to occur for a distance of 4 miles eastward of the granite.

A section below the map shows the structure of the country along a line from west-north-west to east-south-east, from Reskajeage Downs through Dolcoath Mine, Carn Brea, and Carnmenellis granite to Falmouth and Pendennis Point.

Sheet 346 (Newquay) shows the country immediately to north of that represented in Sheet 352, and includes Watergate Bay, Newquay, Perranporth, and St. Agnes. About half the area represented is sea. In ascending order the formations shown are: (1) Dartmouth Beds (Lower Old Red Sandstone), purple and green fine-grained sandy micaceous shales or slates, with occasional bands of grit, and containing fish-remains (*Pteraspis cornubicus*, etc.). They occur in a faulted and much broken anticline which has its crest in Watergate Bay and measures 4¼ miles from east to west by 2 miles from north to south. (2) Lower Devonian Meadfoot Beds, which occupy about one-half of the land area shown, chiefly to south, but also in a narrow band to north of the Dartmouth Beds. The Meadfoot Beds consist of shales, slates, and thin limestones, and seem to rest quite conformably on and to pass gradually down into the Dartmouth Beds. (3) Lower Devonian Staddon Grits on the north, Ladock Beds (basal Devonian) on the south. These consist of silts, sandy slates, sandstones, and coarse grits. The Staddon Grits (so far as shown) occupy an area 3⅓ miles from east to west by 1¼ from north to south in the north-east corner of the map. They strike east-south-east, and this strike if prolonged would make them meet and be continuous with the similar grits of Ladock on the south side of the anticlinal axis (of Dartmouth Beds and Meadfoot Beds). The continuity, however, is broken by the intrusion of the St. Austell granite (not in map), so the southern area is treated separately. The Ladock Beds are continuous with the Grampound Beds of Sheet 352, and occupy an area 13⅓ miles from east to west by 4⅓ miles from north to south at the south of the map 346. Pliocene beds termed St. Agnes Sands and consisting of unfossiliferous sands and clays, forming an old shore-deposit, almost surround St. Agnes Beacon near the south-west coastline. They cover a crescentic area 1⅓ miles long along the curve by ¼ mile broad. Raised Beach deposits, Valley Gravel and Head, Alluvium and Submerged Forest, and Blown Sand are the remaining deposits shown. Granite occurs west of St. Agnes Beacon and at Cligga Head, and is surrounded in each case by an aureole of metamorphism. Elvans or quartz porphyries, lamprophyres or mica traps, and greenstones are shown.

A section below the map shows the structure of the country between Denzell Downs on the north-east cutting across the anticline of Devonian rocks, by Perranporth to St. Agnes Beacon on the south-west.

B. Hobson.

II.—Memoirs of the Geological Survey, England and Wales. Explanation of Sheet 311: The Geology of the Country between Wellington and Chard. By W. A. E. Ussher, F.G.S.; with contributions by H. B. Woodward, F.R.S., and A. J. Jukes-Browne, B.A., F.G.S. 8vo; pp. vi and 68. Price 1*s.* 3*d.*; colour-printed map, 1*s.* 6*d.* E. Stanford, 12–14, Long Acre, London, 1906. (Issued February, 1907.)

THE Geological Survey have issued (price 1*s.* 6*d.*) Sheet 311 (Wellington) of the New Series of one inch to one mile ($\frac{1}{63360}$) colour-printed maps of England and Wales. The area comprised in the map includes the southern suburbs of Taunton at the northern margin, Ilminster close to the eastern border, Chard 3¼ miles from the south-east corner, Wellington 4 miles from the north-west corner. The original one inch Geological Survey map, Sheet 21, was published probably in 1833. The area was resurveyed on the one inch Old Series map between 1870 and 1876, and the geology was transferred to the New Series map, with additions by Mr. A. J. Jukes-Browne, in 1892. The colour-printed edition is dated 1906. The principal additions to the map, which includes the famous Greensand area of the Blackdown Hills, are in the subdivisions of the New Red rocks and the insertion of the Rhætic Beds and superficial deposits. A section below the map shows the structure of the country along a line from north-west to south-east from Kittisford (near Wellington) through Church Stanton to Tatworth (near Chard).

The memoir explanatory of the map is entitled Explanation of Sheet 311: "The Geology of the Country between Wellington and Chard," by W. A. E. Ussher, F.G.S. 1906, pp. vi + 68, with 11 figures, price 1*s.* 3*d.* The strata described include a very small area of Devonian (Pilton Beds) and Lower Culm Measures, a large area of New Red Sandstone with a narrow outcrop of Rhætic, a large spread of Lias and Cretaceous, the latter largely covered by Plateau deposits (Clay with Flints, etc.). Between the five members of the New Red Series no signs of discordance have been found. The Lower Sandstone and Breccia (Permian) exhibit a passage series into the overlying Lower Marls north of the Tone Valley, comparable to that in the South Devon coast section, but which has not been detected in the intervening area. The Pebble Beds show a passage of unconsolidated pebbly sands into hard conglomerate in the vicinity of Thorn St. Margaret. A chapter is devoted to Economic Geology. In an appendix a list (of thirty items) includes the titles of the principal works on the geology of the district, and four complete pages are devoted to an index. B. HOBSON.

III.—NEW GEOLOGICAL SURVEY DRIFT-MAPS, ETC.

THE Geological Survey are issuing a Drift edition of the 4 miles to 1 inch Map of England and Wales. The sheets published (dated 1906) are No. 8, comprising the East Coast of England from Filey Bay to Saltfleet in Lincolnshire (most of the map represents the North Sea), and No. 12 (the sheet immediately to south of No. 8), comprising a large part of Lincolnshire, the Wash, and Norfolk (Lowestoft North station and Peterborough being included). The superficial deposits shown include, under "Drift," loam, sand and gravel, boulder-clay; and under "Recent and Post-Glacial," valley gravel, loam, alluvium, and blown sand.

As compared with the Solid Geology edition, these maps show several improvements—the railway stations are marked, many altitudes are given, more topographical detail is shown, and it is brought more nearly up to date; the colour-printing is excellent. There is only one point that the purchaser is likely to find fault with, and that is the price of the maps. The sheets only measure 15 inches by 22½ inches over the topographical work, whereas the Solid Geology sheets measure 22 by 30 inches over the work, that is, they are twice the size. In each case the price per sheet is 2*s.* 6*d.*

Another new map issued by the Survey is Sheet 341 (West Fleet) of the New Series (colour-printed), 1 inch to 1 mile Map of England and Wales. It comprises a very small triangular bit (about 15 square miles) of Dorsetshire, including part of the Chesil Bank, and shows Oolitic rocks, from the Fuller's Earth to the Portland Sand, Pleistocene Plateau Gravel, Recent and Post-Glacial Valley Gravel, Alluvium, and Shingle, price of map 1*s.* 6*d.* (dated 1905). B. Hobson.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 6th, 1907.—J. E. Marr, Sc.D., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "Note on the Cervical Vertebra of *Zeuglodon* from the Barton Clay of Barton Cliff (Hampshire)." By Charles William Andrews, B.A., D.Sc., F.R.S., F.G.S.

The author gives a brief description of a cervical vertebra from the Barton Clay of Barton Cliff. It is referred provisionally to *Zeuglodon Wanklyni*, a species described in 1876 by Professor H. G. Seeley. The skull on which this description was founded is totally lost, so that this vertebra is the only bone of a *Zeuglodon* from the Barton Clay, and, with the possible exception of a vertebra from the Brockenhurst Beds (which is the type of *Balænoptera Juddi*), the only one found in the British Isles that now exists.

2. "The Origin and Age of the Plateaus around Torquay." By Alfred John Jukes-Browne, B.A., F.G.S.

The existence of high-level plains or plateaus near Torquay has long been known, but since Pengelly's time little attention seems to have been paid to them. Pengelly believed that there were several such plains at different levels, and thought that the time of their production was not very remote. On examination, however, his evidence breaks down, and the author regards the plateaus as portions of one inclined plane.

The plateau-area has an extent of about three miles in length from north to south, and about two in width. Its highest level is found at the foot of the ridge which forms the watershed between Torbay and the estuary of the Teign. From the foot of this a platform stretches southward on each side of Barton at a level of from 350 to 340 feet; south of this is the flat summit of Lummaton Hill (also about 340 feet); and about a mile farther south are the flat-topped hills known as Yaddon and Daison Hills, both about 320 feet, and only separated by a narrow gorge cut by the little stream which flows from Barton to Torquay.

East of these hills we find a plateau-area extending continuously through St. Marychurch and Babbacombe, for a distance of a mile and a half and an average width of half a mile, but cut off abruptly along the coastline. The northern end of this plateau is about 330 feet above Ordnance datum, but it slopes gradually southward, till on Walls Hill its highest part is only 267 feet.

On the west of Torquay the old plain has been so dissected by streams, and so lowered by detritive agencies, that it is almost destroyed. Remnants, however, remain in Waldon Hill (200 feet), Stentiford Hill (230 feet), and Daddy Hole Plain (about 200 feet).

The central hills of Torquay, which are known as Warberry Hill and Lincombe Hill, rise to much greater heights (440 and 400 feet), and stand up as conspicuous eminences above the level of the surrounding plateau.

The evidence as to the age of the planation is next considered. It is proved to be post-Permian by the fact that Permian breccia forms part of the plateau-surface at St. Marychurch. It is also probably post-Cretaceous, because Cretaceous planation is not likely to have removed all the Permian. Its present dissected condition shows that it is older than the Pleistocene, and consequently an Eocene date would agree with local evidence.

The author accepts the Eocene age of the Haldon gravels and of the Bovey deposits, and adduces evidence for a connection between the Haldon plateau and the Bovey basin on the one hand, and between the Aller basin and the Torquay plateau-area on the other. He regards the Bovey basin as a locally deep depression along a line of Miocene deflexion which crosses Devon from north-west to south-east, and believes the plateau-area near Torquay to be the flattened-out extension of this flexure. He thus considers the plateau to be part of the basal plain on which the Eocene deposits lie, and infers that these deposits passed directly out of the Aller basin on to this plateau, burying it to a depth of several hundred feet.

Thus it was on the surface of the Eocene deposits that the existing system of drainage was established.

The Brixham plateau, south of Torbay, presents similar features and appears to be of the same age, but in its case the drainage is northward from higher ground to the south. This plateau can be traced westward through Churston and Galmpton to Stoke Gabriel, where there is high ground both to the north and south of it. It is inferred that this plateau is the site of a second shallow flexure, the axis of which ran nearly west and east, so as to meet and merge into the other line of flexure outside the entrance of Torbay. Incidentally this would explain the formation of Torbay.

II.—February 15th, 1907.—Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec. R.S., President, in the Chair.

ANNUAL GENERAL MEETING.

The Reports of the Council and of the Library and Museum Committee for the year 1906 were read.

The Reports having been received, the President presented the Wollaston Medal to Prof. William Johnson Sollas, F.R.S., addressing him as follows:—

Professor Sollas,—The Council of the Geological Society has this year awarded the Wollaston Medal to you in recognition of the value of your varied and prolonged contribution to the development of Geology. There is hardly a department of our science into which you have not carried the light and impulse of your brilliant and versatile genius. You have united in no ordinary way the qualifications of an accomplished petrographer, an excellent palæontologist, an able stratigrapher, and a philosophical mineralogist, and to this wide range of accomplishment you have added an originality and inventiveness which have introduced notable improvements into the processes of research. I regard it as of special honour and pleasure that it has fallen to me to be the medium of presenting this medal to you. You have long been one of my most esteemed friends, and I trust that I may be allowed, even in this public place, to add my own personal felicitations to those of, I am sure, all the Fellows of the Society that the highest honour which we have to bestow should now be conferred upon you.

If the award is a recognition of past services in the cause of our beloved science, you will, we hope, accept it as no less an augury that we look forward with confidence to much fresh work from your hands in the future. We hope to see a flourishing School of Geology growing up at Oxford under your fostering care, and to welcome from you in the years to come many memoirs not less suggestive and important than those with which you have already enriched the literature of geology.

Professor Sollas, in reply, said:—

Mr. President,—I deeply appreciate the honour conferred upon me by the Council, and if by any means I could be reconciled to the sense of my own insignificance, awakened by the recollection of the many illustrious names that have preceded me in this place before the President's chair, it would be by your kind, I fear too kind, words, and the favour with which they have been received by the Fellows of this Society.

It is by no merit of mine that I am a lover, an ardent lover, of geology, for I feel, perhaps with a lover's partiality, that our gracious mistress, bountiful as she is fair, requires only to be seen as she truly is to captivate at once all hearts. I have found in her service a perpetual delight, and if your kind wishes should be fulfilled shall ever continue to do so, for she repays our constancy with a variety that never stales.

I know how close is the interest taken by you, Sir, in the cause of Geology at Oxford; it has been a frequent source of encouragement to me, and the hope you now express is that which lies nearest to my own heart. As a teacher I increasingly feel with advancing years how great is my debt to my masters, Huxley, Ramsay, Bonney, and, Sir, yourself, for I have been a diligent student of your teaching ever since the appearance of "The Scenery of Scotland" in 1865. But to you, Sir, and to my revered tutor, I am indebted not only for direct instruction, but for the light of example, the privilege and stimulus of friendship, and indeed for those very opportunities by which I stand here to-day. I count it, therefore, not the least of my good fortune that I receive the Wollaston Medal from your hands.

The President then presented the Murchison Medal to Mr. Alfred Harker, F.R.S., addressing him in the following words:—

Mr. Harker,—The Murchison Medal has been assigned to you as a testimony of the Council's appreciation of the importance of your contributions to Petrographical and Structural Geology. You had already distinguished yourself by your studies in cleavage, by the zeal and success with which you had thrown yourself into the pursuit of petrographical research along those modern paths in which this department of our science has been so transformed and enlarged, and lastly by the skill which you had shown in the field investigation of the ancient igneous rocks of North Wales and of part of the Lake District. With this reputation already established and yearly growing, you were induced, at my request, to enter the Geological Survey. Although the circumstances under which you joined that service formed a new departure in its usages, I have always felt that on no part of my long connection with the Survey could I look back with more satisfaction than on the arrangements which enabled us to secure your services. You speedily acquired the skill of a practised surveyor, and among the hills of Skye and Rum you had an opportunity of mapping some of the most complicated and deeply interesting pieces of volcanic geology in this country. Having had from time to time opportunities of visiting you on the ground, I can bear witness both to the bodily vigour and endurance and to the geological enthusiasm and insight with which you climbed crags and peaks on which no geologist had set foot before you. The maps and memoirs which you have produced of these portions of the Inner Hebrides will always remain as a monument of your prowess as a field geologist and petrographer.

In handing you this Medal, which bears the honoured name of Murchison, let me wish you, on the part of the Council and of the Society at large, health, leisure, and opportunity, that you may enjoy a long, useful, and distinguished career.

Mr. Harker replied as follows:—

Mr. President,—I wish, in response to what you have said, to express my very sincere acknowledgements to the Council for the distinction which they have conferred upon me. The pleasure with which I first received news of this honour has since been enhanced by the knowledge that my gratification is shared by friends and fellow-workers, and it is now crowned by the graceful words with which you have accompanied the presentation.

In my work in Skye, to which you have made kind reference, it has been my privilege to tread ground rendered classic by the labours of some of the masters of our science; and I hold it peculiarly appropriate, as it is eminently pleasing to myself, that this mark of the generous appreciation of the Council should be conveyed by one of those my predecessors—by one, moreover, who first directed my steps in a field which he had already made his own. That the work has been a labour of love I need not say to any geologist who has felt the fascination of the West Highlands—least of all, Sir, to yourself. Where the work is its own reward, so flattering a recognition as this might perhaps be deemed an unearned addition. I take leave, however, to regard it as in some part an encouragement for the future, and with it I must accept the responsibility of justifying to the best of my powers the choice of the Council.

To me, finally, this Medal will be in a special sense a memento of the ten years which I spent so pleasantly on the Geological Survey of Scotland: not only because the Medal itself was founded by a former chief of the Survey, and comes to me from the hand of one of his successors, but also because this award adds my name to a list which includes those of yourself, who, as Director-General, despatched me to the island which you knew so well; of Dr. Horne, head of the Scottish branch, my constant friend and counsellor; of Dr. Peach, my immediate superior on the Survey; and (last year) of Mr. Clough, the colleague who initiated me into the craft of geological surveying, setting a standard to which I fear his pupil has not often attained.

In handing the Lyell Medal, awarded to Dr. Joseph Frederick Whiteaves, F.R.S. Can., to Lord Strathcona, for transmission to the recipient, the President addressed him as follows:—

Lord Strathcona,—The Lyell Medal of the Geological Society is this year awarded to Dr. Joseph Frederick Whiteaves as a mark of the Council's appreciation of his prolonged and valuable contributions to the Geology and Palæontology of Canada. As a young man, before he settled in the New World, he had already shown his scientific bent by several published papers on the land and fresh-water mollusca and on the fossils of some of the Oolitic formations of Oxfordshire. Half a century ago he transferred his home and his geological energy to Canada, and from that time until now his scientific activity has known no pause. In 1876 he was appointed to succeed the illustrious Billings as Palæontologist to the Geological Survey of Canada. In that official capacity he found increased opportunity of studying the fossils that were brought to the Survey Museum from the eastern provinces, from Manitoba, and from the far shores of the Pacific Ocean. Thus every fossiliferous formation in the wide Dominion has come under his review, and he has described many new forms in various grades of the animal kingdom. Following the path so admirably opened up by his predecessor, Dr. Whiteaves has amply sustained the scientific reputation of the Canadian Geological Survey, and has made solid contributions of great value to Palæontology.

In requesting you, Lord Strathcona, as High Commissioner for Canada, to be so good as to transmit this Medal and its accompanying cheque to our esteemed colleague in Ottawa, I would beg you at the same time to assure him that the Geological Society values his services to our science, takes an interest in his welfare, and sends its cordial wishes for the continued prosperity of the great scientific institution in which he has laboured so long, and to the renown of which he has so greatly contributed.

Lord Strathcona, in reply, expressed the pride and pleasure which he felt in receiving the medal on behalf of a palæontologist the great value of whose work had been known to him for many years. He recalled the inception of the Canadian Geological Survey under Sir William Logan, and remarked that in showing its appreciation of the merits of Dr. Whiteaves, one of the most indefatigable workers on that Survey, the Council of the Society had done honour to the Survey and to Canada.

The President then handed the Bigsby Medal, awarded to Mr. Arthur William Rogers, M.A., F.G.S., Director of the Geological Survey of Cape Colony, to Mr. G. W. Lamplugh for transmission to the recipient, addressing him as follows:—

Mr. Lamplugh,—The Bigsby Medal has been adjudicated by the Council to Mr. A. W. Rogers in appreciation of his important labours in South African Geology. For more than ten years he has been at work in Cape Colony, not infrequently under difficulties which, in older countries like our own, can hardly be realized. His numerous reports, whether prepared by himself alone or conjointly with his colleagues on the Geological Commission, and published in the Commission's annual volumes, have materially increased our knowledge of the geological structure of the southern part of the African continent. Besides these official memoirs, he has published alone, and also in conjunction with his able colleague Professor E. H. L. Schwarz, in the "Transactions of the South African Philosophical Society," some important papers in which striking evidence has been brought forward in favour of old glaciation during more than one geological period in South Africa. His volume published in London two years ago, under the title of "An Introduction to the Geology of Cape Colony," reveals the patient and cautious character of his work, and shows how firmly and quietly the foundations of our knowledge of the geological history of that interesting region are being laid.

This Medal is always given to one who is under 45 years of age, and thus, to use the words of its venerable founder, "probably not too old for further work, and not too young to have done much." In asking you to be so good as to transmit this award to Mr. Rogers, I should be glad if you would accompany it with an expression of our good wishes for himself, and of our continued interest in the important and useful work of the Geological Survey which he so ably superintends.

Mr. Lamplugh, in reply, said:—

Mr. President,—It gives me deep satisfaction to receive this Medal on behalf of Mr. Rogers, for, like all geologists who took part in the visit of the British Association to South Africa, I have learned to appreciate very highly the results of his work and to admire the patient sincerity of the worker.

Mr. Rogers has sent a letter which, Sir, with your permission, I will read:—

"Geological Commission, South African Museum, Cape Town, Jan. 15th, 1907.

"To the Council of the Geological Society of London.

"Gentlemen,—I thank you most heartily for the honour which you have done me by the award of the Bigsby Medal. I take it as a recognition that the Geological Survey of this Colony has been carried out on sound lines, and as an expression of your hope that the work will continue.

"The official geologists of the present generation in South Africa are more fortunate than their predecessors in having instructions which allow them to work steadily at the geological structure of the country, unhampered by frequent orders to investigate some local details of passing interest. Thus a firm foundation is being laid for future work, both scientific and economic. In Cape Colony, which was the first of the South African countries to institute a systematic survey, the Geological Commissioners have pursued this policy from the commencement of the survey under their control; my predecessor in charge of the work, Dr. G. S. Corstorphine, always kept this end in view, and I have done the same.

"In examining the manuscript map (dated 1859) and sections made by the first official geologist at the Cape, Andrew Wyley, once a Fellow of this Society, it is impossible not to perceive that, had he been allowed to continue his work, the geology of the Colony would long ago have been well known, even as regards those parts where to-day the broad outlines are still uncertain.

"Circumstances prevent the establishment of a lavishly equipped Survey in this Colony, and there are many problems which have to be left almost untouched because their investigation requires too detailed work; but your award will make Cape geologists feel that their efforts are warmly appreciated, and I believe that my colleagues past and present will share my gratification.

"For myself, I must say that your generous gift will always urge me to do better work, and my only regret is that I am unable to receive the Medal personally from a man whose writings have been a constant source of instruction and pleasure to me ever since geology began to be the great interest of my life.—ARTHUR W. ROGERS."

In handing the Balance of the Proceeds of the Wollaston Donation Fund, awarded to Dr. Arthur Vaughan, B.A., to Professor W. W. Watts, for transmission to the recipient, the President addressed him in the following words:—

Professor Watts,—The Balance of the Proceeds of the Wollaston Donation Fund has been assigned to Dr. A. Vaughan, as a mark of the Council's appreciation of the excellence of his contributions to Geology, and in particular of his application of the zonal method of stratigraphical classification to the Carboniferous Limestone of this country. I had often wondered why this method, which was so successfully adopted many years ago for the corresponding portion of the Carboniferous system of Belgium, should never have been similarly applied to our own great Limestone deposit. Dr. Vaughan has now demonstrated, by a careful study of the corals and the brachiopods, how completely it is available here, and the basis of investigation which he has laid so firmly in the Bristol region will doubtless prove to be one upon which the stratigraphy of the Carboniferous Limestone throughout the rest of the British Isles may be satisfactorily worked out. When you transmit to him this award, will you assure him that the Society looks forward with much interest to the continuation of his important labours?

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Dr. Felix Oswald, addressing him as follows:—

Dr. Oswald,—The Council has awarded to you the Balance of the Proceeds of the Murchison Geological Fund, in recognition of the value of your contributions to our knowledge of the Geology of Armenia. The remarkable volume which you have published on this subject affords ample evidence of your keen powers of observation and of the indomitable courage with which you have done pioneer work in a little-known country and with which, also, you have laid your results before the world.

Your treatise is, in one respect, probably unique in geological literature. To surmount the difficulties presented by the expense of publication, you purchased a hand-press, learned the art of type-setting, and laboriously printed off the whole book, page by page, with your own hand while the numerous sections, maps, and plates of fossils were likewise drawn, reproduced, coloured, and printed off by yourself. The volume is dedicated to your wife, who will share your pleasure at this recognition of your labours, and to whom with yourself I desire to convey the good wishes of the Geological Society.

In presenting a moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Thomas Crosbee Cantrill, B.Sc., the President addressed him in the following words:—

Mr. Cantrill,—The Council has this year awarded to you a moiety of the Balance of the Lyell Geological Fund in recognition of the quality of your contributions to Geology, more particularly in relation to the stratigraphy of the formations from the base of the Lias down into the older Palæozoic rocks. Your early paper on Wyre Forest afforded good promise of your future success. Since it appeared you have served for upwards of ten years on the Geological Survey, where, as I can personally testify, your work has been characterized by remarkable carefulness and precision. It is to me a great gratification to hand this award to a former Survey colleague, and to wish you continued activity and success in your career.

The President then presented the other moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Thomas Sheppard, F.G.S., addressing him as follows:—

Mr. Sheppard,—The other moiety of the Balance of the Lyell Geological Fund has been assigned by the Council to you in acknowledgment of the useful additions made by you to our knowledge of the Pleistocene Geology of East Yorkshire; of the value of your bibliographical work and your labours in the Hull Museum; and of the excellence of your volume on "Geological Rambles in East Yorkshire," which contains much information presented by you in a popular and attractive form.

The President then proceeded to read his Anniversary Address, giving first of all obituary notices of several Fellows deceased since the last annual meeting, including Professor Eugène Renevier (elected Foreign Member in 1888), Professor S. L. Penfield (elected Foreign Correspondent in 1896), G. C. Churchill (elected a Fellow in 1864), the Rev. J. F. Blake (el. 1868), C. E. De Rance (el. 1869), R. P. Greg (el. 1853), J. G. Goodchild (el. 1884), Cav. W. P. Jervis (el. 1860), W. Cunnington (el. 1854), G. F. Harris (el. 1885), and P. Emary (el. 1897).

He then sketched out the arrangements contemplated for the celebration of the Society's Centenary. Enquiry had shown that the last week in the month of September appeared to be, on the whole, the time which would be most generally convenient to Fellows and guests in this country and to visitors from abroad. It was therefore intended that the celebration should take place at that time. Every Fellow of the Society would, of course, receive due notice, as well as a detailed statement of the arrangements when these had been finally settled. Invitations to attend the meetings would be immediately sent out to all the Foreign Members and Foreign Correspondents. Geological Societies, Geological Surveys, and learned institutions which had a geological side, would be asked to send delegates. Personal invitations would also be addressed to geologists of note in the Old and the New World who might not be already enrolled in the foreign lists of the Society. It was hoped that to these various invitations there would be a friendly response, either by personal representation or in writing. They might not impossibly be privileged to see a larger company of geologists assembled together in this country next September than had ever been gathered together here before.

It was thought that the official programme might extend over three days in London. The arrangements for each of these three days were under consideration; but he might mention now that he proposed to give his postponed address as the *pièce de résistance* of one of the forenoon or afternoon meetings. In that address he would offer a sketch of the state of geological science outside of Britain at the time when the Geological Society of London was founded, and indicate the external influences that affected its start. By this choice of a subject he hoped to interest the foreign guests, while at the same time inviting the Fellows of the Society into a domain of the history of science which was perhaps less familiar than it deserved to be.

The chronicle of the Society itself during the first hundred years of its existence had been carefully and fully compiled from all available sources by Mr. Horace B. Woodward, F.R.S. His volume was now in the printer's hands, and would be in the hands of Fellows in the course of the Summer.

Excursions to places of geological note in this country would probably be arranged, some to precede and others to follow the meeting in London. The various museums and places of interest in the Metropolis would, of course, be shown to the expected visitors; and there would doubtless be no lack of public and private hospitality. It was anticipated that the Universities of Oxford and Cambridge would both receive the foreign guests. But the details of these various arrangements had still to be worked out.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council:* H. H. Arnold-Bemrose, J.P., M.A.; Professor S. H. Cox, F.C.S., Assoc. R.S.M.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S.; Professor E. J. Garwood, M.A.; Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec. R.S.; W. H. Hudleston, M.A., F.R.S., F.L.S.; F. L. Kitchin, M.A., Ph.D.; G. W. Lamplugh, F.R.S.; Professor C. Lapworth, M.Sc., LL.D., F.R.S.; R. Lydekker, B.A., F.R.S.; J. E. Marr, Sc.D., F.R.S.; H. W. Monckton, Treas. L.S.; F. W. Rudler, I.S.O.; Professor W. J. Sollas, Sc.D., LL.D., F.R.S.; L. J. Spencer, M.A.; A. Strahan, Sc.D., F.R.S.; C. Fox Strangways; J. J. H. Teall, M.A., D.Sc., F.R.S.; R. H. Tiddeman, M.A.; Professor W. W. Watts, M.A., M.Sc., F.R.S.; H. Woods, M.A.; A. Smith Woodward, LL.D., F.R.S., F.L.S.; and Horace B. Woodward, F.R.S.

Officers:—President: Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec. R.S. *Vice-Presidents:* J. E. Marr, Sc.D., F.R.S.; Professor W. J. Sollas, Sc.D., LL.D., F.R.S.; Aubrey Strahan, Sc.D., F.R.S.; and J. J. H. Teall, M.A., D.Sc., F.R.S. *Secretaries:* Professor E. J. Garwood, M.A., and Professor W. W. Watts, M.A., M.Sc., F.R.S. *Foreign Secretary:* Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer:* Horace W. Monckton, Treas. L.S.

III.—February 27th, 1907.—Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "On the Lower Ordovician Succession in Scandinavia." By William George Fearnsides, M.A., F.G.S.

The paper is a stratigraphical account of the *Dictyonema* Shales, the *Ceratopyge* Beds, the *Didymograptus* Shales, and the *Orthoceras* Limestone of Sweden and Southern Norway, and is based upon field observations of Scandinavian type localities made by the author during the Summer of 1906. The beds are discussed under the following headings:—

(C) *Didymograptus* Shales and *Orthocera*kalk,
(B) Glauconite Shales and *Ceratopyge*kalk,
(A) *Dictyonema* and *Bryograptus* Shales,

which are found to be applicable to all the sections visited.

For purposes of ready correlation with the British Tremadoc rocks, the upper part of the *Acerocaris* zone of the Alum Shales is considered along with Division A, and the presence of trilobites of Ordovician type and related to those of the *Ceratopyge*kalk in that as well as in the *Dictyonema* Beds is emphasized. It is also held that the branching graptolites of Division A show a progressive evolutional divergence from an original *Dictyonema* through *Dictyograptus flabelliformis* to the true graptolites of Clonograptid or Bryograptid types, and through *D. norvegicus* to the so-called 'dendroid graptolites.' The gradual replacement of the western type of Alum Shales of this division by the sandy beds with *Obolus* in Northern Öland and the Baltic Provinces is discussed, and is considered as an early manifestation of the crustal instability which brought about the curious vicissitudes of the Glauconite Shale period. Many of the phenomena at the base of Division B are suggestive of an unconformity, and in all Swedish areas except Skåne the succession from A to B is shown to be incomplete. In general, the base of Division B has much the aspect of the Cambridge Greensand, and the Glauconite Shales as a whole mark a period during which the alternating processes of deposition and erosion were nicely balanced. A curious small-scale erosion phenomenon occurring intermittently throughout Division B is redescribed under the name 'Korrosionsgrupper,' and along with the variable detailed succession of the beds is considered as a further proof of discontinuous sedimentation throughout the period. Division C of *Didymograptus* Shales and their equivalent *Orthocera*-kalk is discussed only in outline. Both shales and limestone pass downwards continuously into the highest *Ceratopyge* Beds, both in lithology and fauna, and the difference between the lowest *Orthoceras* Limestone (Planilimbatenkalk) and the higher limestone of the *Ceratopyge*kalk is almost imperceptible.

This stratigraphical evidence is then considered in its bearing upon the question of the definition of the boundary between the Cambrian and the Ordovician Systems; and the author follows the Scandinavian authorities in considering that, so long as the *Dictyonema* horizon is available, the evidence of sudden faunistic change within the series discussed is too slight to warrant a palæontological separation of the systems at any other horizon. A comparison of the British Tremadoc and Arenig Series with these Scandinavian rocks concludes the paper; and it is maintained that the time has now arrived for British geologists to come into line with their Continental brethren, and to include the *Dictyonema* and the overlying Tremadoc Beds as the lowest series of the Ordovician System.

2. "The occurrence of Pseudomorphous Pebbles of Pyrites at the Crown Reef Mine (Witwatersrand)." By Cuthbert Baring Horwood, A.R S.M., Assoc. M. Inst. C. E., F.G.S.

Reference is first made to the existence of calcite 'pebbles' in the Main Reef, which Mr. Julius Kuntz believes to be due to the replacement of quartz by calcite. Pellets of iron bisulphide known as 'buckshot' occur at the Rietfontein 'A' Mine in the Buckshot Reef: they exhibit radiate fibrous structure, and are probably of concretionary origin. At the Crown Reef Mine a few 'pebbles' of pyrites, some measuring as much as an inch in length, occur in a narrow band of conglomerate at the contact of the reef with a basic dyke. It is conjectured that the mineralising solutions which deposited the pyrites (together with some, if not all, of the associated gold) ascended along the fractures due to the intrusion of the dyke, and found an easy course along the small conglomerate bed, where they replaced some of the quartz pebbles with pyrites, being kept up by a band of shale underneath the conglomerate.

IV.—March 13th, 1907.—Aubrey Strahan, Sc.D., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "A Silurian Inlier in the Eastern Mendips." By Prof. Sidney Hugh Reynolds, M.A., F.G.S.

An account of the rocks with which the paper mainly deals was brought before the Society on February 7th, 1906 (see Abstract of Proc., Geol. Mag., 1906, p. 142); but, owing to the discovery just before the meeting of Silurian fossils in material thrown out by moles and rabbits, the paper was withdrawn and further work, including the digging of a series of seven trenches, was carried out. This proved that the fragmental igneous rock is of two types:—(1) Normal fine-grained tuff, from which in three localities over thirty species of Silurian (probably Llandovery) fossils were obtained and have been identified by Mr. F. R. Cowper Reed: the tuffs are seen at Sunnyhill to underlie the trap. (2) A remarkable coarse ashy conglomerate, the nature and relation of which to the other rocks are both obscure. The following four possibilities with regard to the nature of this rock are discussed in some detail:—(*a*) That it may be the basement conglomerate of the Old Red Sandstone; (*b*) that it may be an aqueous deposit of the same general age, and belonging to the same igneous series as the associated trap and normal tuff; (*c*) that it may be an old river-gravel, deposited during a terrestrial period subsequent to the fossiliferous Silurian and prior to the Old Red of the district; and (*d*) that it may represent the necks of the volcanoes from which the trap and the normal tuff were ejected. The author is of opinion that the fourth of these possibilities agrees best with the observed facts. The paper concludes with a comparison between the Mendip Silurian rocks and those of Gower and Tortworth, in both of which localities it appears that the upper beds of the Silurian System are unrepresented.

2. "On Changes of Physical Constants which take place in certain Minerals and Igneous Rocks on the Passage from the Crystalline to the Glassy State; with a short Note on Eutectic Mixtures." By James Archibald Douglas, B.A., F.G.S.

After giving an account of previous experiments in the direction of determining the physical changes accompanying the fusion of rocks and minerals, and their re-solidification into a glassy condition —experiments which are in many cases open to sources of considerable error—the author describes the electrical apparatus employed by himself. Powdered rock of known specific gravity is fused as often as required in a loop of platinum-ribbon. The fused product is powdered, examined with the microscope, and then placed in a diffusion-column, by the use of which errors due to the few small bubbles or unfused mineral particles, on the few occasions when these exist, are eliminated. The diffusion-column is sealed in a glass tube. Acid rocks were found to increase 6 to 10 per cent. in volume, intermediate rocks 5 to 7 per cent., and basic rocks chiefly less than 6 per cent. Of the minerals tested, pargasite underwent the greatest expansion, albite gained 10 per cent., while in anorthite and leucite the increase was less than 4 per cent. It is pointed out that this expansion would be a very effective force in the case of the melting of rock-magmas kept solid by pressure. Experiments were also made in order to ascertain the melting-points of the rocks and minerals experimented upon: these were found to range from 1260° C. for rhyolite to 1070° C. for Clee Hill dolerite. The refractive indices of the glasses were determined in dense fluids. In determining the melting-points of individual minerals, the author's results agree fairly closely with those of Day & Allan, but differ from those of Joly & Cusack. An attempt was made to find experimentally the eutectic proportions of quartz and felspar. It was found impossible to reproduce in the laboratory the conditions which, in nature, seem to have existed during the formation of pegmatites. On the other hand, a mixture of orthoclase and albite gave a melting-point lower than those of either mineral taken separately.

V.—MINERALOGICAL SOCIETY.

Tuesday, January 29th.—Professor H. A. Miers, F.R.S., President, in the Chair.

Experiments bearing on the order of crystallisation of Rock-constituents, by Professor H. A. Miers. The general results of experiments made by Miss F. Isaac and Professor Miers with mixtures of salol and betol in all proportions were described; the experiments have established the supersolubility curves even beyond the points where they cross below the eutectic temperature. Owing to the fact that the main separation of crystals in the cooling mixtures takes place only when the liquids have been supercooled to temperatures given by the supersolubility curves, it has been found (1) that in general the mixtures do not solidify as a eutectic mixture, (2) that according to the conditions of supercooling either substance could be made to crystallise before the other in mixtures approaching the eutectic in composition. It was suggested that these results are applicable to the solidification of many rocks and alloys.—Serpentine Rock from the Tarnthaler Köpfe, Tyrol, by Dr. A. P. Young. The minerals found in the serpentine are diopside, tremolite, clinochlore, picotite, magnetite, iron pyrites, and a fibrous mineral referred to antigorite. The latter mineral is regarded as holding a place between the micas and chlorites. On the surface of the serpentine are projecting bastite pseudomorphs coated with films of silvery lustre. The serpentine is a non-foliated intrusive core, which on the borders is highly foliated and passes into talc bearing phyllites.—A simple tabular arrangement of the 32 crystallographic classes, by Dr. J. W. Evans. The table is based on the character of the symmetry of the principal zone axis or zone axes. Each column contains classes with the same rotational symmetry round the axis, and each row those which agree in the other symmetrical characters of the axis.—A new model of crystal-refractometer, by Dr. G. F. Herbert Smith. This instrument is identical in principle with that previously described, and is intended for use with large mineral specimens and mounted gem-stones. No part extends above the level of the plate holding the dense-glass hemisphere. Further, the optical combination has double the focal length of the earlier form and provides consequently greater refinement. — Isomorphism as illustrated by certain varieties of magnetite, by Professor B. J. Harrington. Analyses are given of specimens of magnetite from St. Joseph du Lac, Canada, and from Magnet Cove, Arkansas, both showing the unusual combination of octahedron and trapezohedron {311}. The Canadian specimen contained about 5 per cent. of $Ti\,O_2$, 8 per cent. of $Mn\,O$, and 3 per cent. of $Mg\,O$; and the specimen from Arkansas about 10 per cent. of $Al_2\,O_3$, 2 per cent. of $Ti\,O_2$, 2 per cent. of $Mn\,O$, and 9 per cent. of $Mg\,O$.—Mr. Fleischmann exhibited a collection of zeolites from Japan, Dr. Evans an objective giving a flat field with convergent light, and Professor Miers a goniometer to be used for the measurement of the refractive indices of cooling solutions, for which purpose it is provided with means for maintaining a constant temperature for any desired period.

VI.—Palæontographical Society.

The sixtieth Annual Meeting of the Palæontographical Society was held at the apartments of the Geological Society, Burlington House, on March 16th, Dr. Henry Woodward, F.R.S., President, in the chair. The report of the Council congratulated the Society on its continued prosperity, and the value and variety of the Monographs which it still received for publication. The funds had been augmented by a special sale of back stock to members, but the normal income showed a gradual decline owing to the difficulty of obtaining new personal subscribers to replace those lost by death. The Carnegie Trust for the Universities of Scotland paid for the production of five plates of Old Red Sandstone Fishes illustrating Dr. Traquair's Monograph issued in 1906. The Rev. J. F. Blake, Mr. Thomas Leighton, and Miss Caroline Birley were among the members deceased since the last annual meeting. Dr. Henry Woodward, Dr. G. J. Hinde, and Dr. A. S. Woodward were re-elected President, Treasurer, and Secretary respectively. Messrs. J. Hopkinson, W. D. Lang, H. Woods, and G. W. Young were elected new members of Council.

VII.—Zoological Society.

At the meeting of the Zoological Society on March 19th, 1907, Mr. H. F. Standing, M.Sc., exhibited and described a large series of remains of comparatively gigantic extinct lemurs, which he had discovered in a marsh in Madagascar. He arrived at the following general conclusions as to the relationships of these animals and the Prosimiæ in general:—

1. The recent Indrisinæ *Chiromys*, *Mesopropitheous*, *Palæopropithecus*, *Archæolemur*, and *Hadropithecus* are all more or less specialized representatives of one common Prosimian stock.

2. Specialization has taken place in various directions and to very varying degrees among the different genera enumerated; *Archæolemur*, *Hadropithecus*, and *Mesopropithecus* retaining on the whole the greatest number of pithecoid characters.

3. Even the least specialized forms have undergone retrogressive changes as compared with the ancestral Tertiary stock from which they, in common with the extant Indrisinæ, are derived. This is notably true as regards the condition of the frontal region of the brain.

4. A comparison of the least specialized members of this Indrisine group of Prosimiæ with the various families of the Old and New World Monkeys, shows in several characters closer affinities with the latter than with the former (e.g., auditory bullæ, traces of primitive dentition, procumbent lower incisors, tendency to lose third molar, platyrhine condition of nasals).

5. A comparison of the Malagasy Lemurinæ, recent and sub-fossil, with the various genera of the Indrisine group supports the belief that retrogressive specialization has proceeded even further in their case than in that of the recent Indrisinæ. This retrogressive specialization has in general proceeded on similar lines in the two groups, though the deviations from the primitive dental formula are less pronounced among the Lemurine than among the Indrisine genera.

6. The members of the family of the Lemuridæ outside of Madagascar are found in scattered groups over a wide area in the Old World and bear the marks of a decadent group. All are nocturnal, and many are curiously specialized.

7. A comparison of the various genera of Lemuridæ with one another and with the New World Monkeys, both recent and fossil, leads to a strong presumption that these families as well as the Malagasy Indrisine group have had a common origin.

8. In view of the recent additions to our knowledge of the Prosimiæ and of their close relations to the Apes, it seems no longer necessary, or indeed possible, to separate the Primates into the two suborders of Lemuroidea and Anthropoidea.

Most of the specimens described by Mr. Standing belong to the Malagasy Academy, Antananarivo, but a typical and extensive selection has been acquired by the British Museum (Natural History).

CORRESPONDENCE.

MARINE RIPPLE-MARK.

Sir,—In your issue for February, p. 96, your correspondent Mr. A. R. Hunt quotes one among the many experiments I showed in my lecture to Section G at Cambridge, and deduces from it that my "results and conclusions . . . . have practically no bearing on the phenomena of the sea-shore and sea-bottom."

Even had I shown only this one experiment, such a statement would surely have been somewhat sweeping; but as I actually showed at the lecture "a series of periodically oscillating waves moving in one direction over a fixed bottom, and expending themselves on a sandy shore," and proved that under such waves ripples formed exactly as they did in the moving tank with vertical sides. I can only suppose that Mr. Hunt was not at the lecture, and is judging without having seen the experiments. HERTHA AYRTON.

71, NORFOLK SQUARE, W.
February 28th, 1907.

OBITUARY.

SIR FRANCIS TRESS BARRY, BART., D.L., J.P., F.S.A.

BORN 1825. DIED FEBRUARY 28, 1907.

WE regret to announce the death of Sir Francis Tress Barry, Bart., of Keiss Castle, Caithness, N.B., on the 28th February, at his Berkshire residence, St. Leonard's Hill, near Windsor, in his 83rd year, after a long and severe illness. The late Baronet filled the position of British Vice-Consul for the province of Biscay, Spain, in 1846, and was Acting Consul for the provinces of Biscay, Santander, and Guipuzcoa in 1847. In 1854 Mr. Barry was offered by the Earl of Clarendon the appointment of British Consul at Madrid, but was obliged to decline it as he had established himself as a merchant at Bilbao. Returning to England shortly after, he joined his brother-in-law, Mr. James Mason, in the exploitation of the famous San Domingo copper-mines in Portugal, from which time many honours fell to him. He was decorated with the Order of Christ by the King of Portugal in 1863, five years after being raised to the rank of Commander of the same Order. In 1880 he was decorated by the King of Spain with the Cross of Naval Merit (Second Class). He acted as Consul-General in England for Ecuador in 1872. Sir Francis represented Windsor in the Conservative interest from 1890 to 1906. He was created a Baronet in 1899, and also held the Portuguese title of Baron de Barry. Sir Francis is succeeded by his son, Major Edward Arthur Barry, who was born in 1858.—*Morning Post*, March 1st, 1907.

For many years Sir Francis Barry devoted himself, when at Keiss Castle, to the exploration of the numerous prehistoric towers on his estate in Caithness, known as 'Brocks.' These buildings, constructed of flat flags of Old Red Sandstone *without any mortar*, were extremely well built, circular in form, and originally some 30 feet in height, with solid walls of enormous thickness. Their history is quite unknown. One is still standing on Pomona, near Kirkwall, Shetlands. Those in Caithness have been destroyed, save their foundations, which were dug out by Sir Francis Barry. He proved that they had been inhabited for long periods, the débris, or middens, containing remains of the elk, reindeer, red deer, wolf, wild boar, pig, *Bos*, sheep, goat, and various birds; of Aves the most interesting was the great auk (*Alca impennis*), of which a considerable number of entire skulls, etc., were obtained. It was Sir Francis Barry's intention to publish a full account of these most interesting prehistoric remains, but save for a small octavo pamphlet they have no record by him.

THE GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. V.—MAY, 1907.

ORIGINAL ARTICLES.

I.—NOTES ON SOME UPPER CRETACEOUS FISH-REMAINS FROM THE PROVINCES OF SERGIPE AND PERNAMBUCO, BRAZIL.

By ARTHUR SMITH WOODWARD, LL.D., F.R.S., of the British Museum.

(PLATE VII.)

I AM indebted to Professor Orville A. Derby for the opportunity of studying some fish-remains from the Cretaceous of North-East Brazil, which were examined by the late Professor Cope and partially described by him, without illustrations, in 1886. I had the privilege of seeing some of these fossils at Philadelphia in 1890, and made a few notes which were incorporated in the British Museum Catalogue of Fossil Fishes. I have now undertaken a renewed and more detailed study of the collection, which suggests the desirability of publishing the following supplementary observations.

ENCHODUS SUBÆQUILATERALIS, Cope. (Pl. VII, Figs. 1, 2.)

1886. *Enchodus subæquilateralis*, E. D. Cope: Proc. Amer. Phil. Soc., vol. xxiii, p. 3.

This species is represented only by palatine bones ('premaxillaries' of Cope) and by a tooth probably of the dentary bone, from Maria Farinha, Province of Pernambuco. The type-specimen (Pl. VII, Fig. 1) exhibits the palatine tooth, already described by Cope. A second specimen (Fig. 2), exposed from the inner aspect, shows that the palatine bone is short and stout, with the ethmoid articulation extending to its anterior end, where the tooth is fixed and directed downwards.

PALÆOBALISTUM FLABELLATUM, Cope, sp. (Pl. VII, Fig. 3.)

1886. *Pycnodus flabellatus*, E. D. Cope: Proc. Amer. Phil. Soc., vol. xxiii, p. 6.
1895. *Palæobalistum flabellatum*, A. S. Woodward: Cat. Foss. Fishes Brit. Mus., pt. iii, p. 275.

The only known example of this interesting Pycnodont is exposed from the right side and shown of one-half natural size in Pl. VII, Fig. 3. It lacks the greater part of the head, besides the front half of the dorsal and ventral borders, but is sufficiently well preserved to leave no doubt as to its generic determination. Immediately behind the rather large orbit (*orb.*) a cluster of slender ossified gill-supports is seen, and below this is part of the widely expanded left preoperculum (*pop.*) exposed from its inner face. In the axial skeleton of the trunk there are traces of the expanded bases of the neural and hæmal arches, which must have nearly encircled the persistent notochord; and just above these expansions in the neural arches of the abdominal region the interdigitating plates, which form a rigid connection between the bases of the neural spines, are conspicuous. The ribs are winged as described by Cope, but the appearance of a "continuous wall" noted by him is partly due to an inner view of the underlying scales of the left side of the fish. Impressions show that the hæmal spines within the caudal fin are fan-shaped. The slender left clavicle still retains traces of its inferior expansion (*cl.*), which is mistaken by Cope for a coracoid bone; while the series of basal bones of the pectoral fin is obviously incomplete, and so does not place the Pycnodontidæ in the Isospondyli, as supposed by Cope. All the fins are very imperfect, and it is impossible to determine how many rays were originally present in the dorsal and anal fins, which are incomplete in front. There is thus no reason for Cope's conclusion that the anal fin is unusually short. The caudal fin, which is shown chiefly as an impression, displays the peculiar shape characteristic of *Palæobalistum*. Remains of the squamation occur over the whole of the abdominal region and, though more delicate, over the middle part of the flank of the caudal region; but the scales are represented chiefly by their thickened ribs ('rhabdopleurs' of Cope), by which the transverse rows are clearly spliced together in the usual manner. Cope did not observe this splicing, but described the 'rhabdopleurs' as "not segmented." As noted by him, the number of transverse rows of scales is equal to that of the vertebral segments. No traces of scale-ornament are observable.

The condition of the vertebral column and the shape of the caudal pedicle and caudal fin prove that the Pycnodont now described belongs to the genus *Palæobalistum*, which occurs both in the Upper Cretaceous and in the Eocene of the Old World. It differs from *P. Ponsorti* (Upper Cretaceous, Marne, France), in having the scales continued over the middle of the flank of the caudal region; but agrees in the latter respect both with the type-species, *P. orbiculatum*[1] (Upper Eocene, Monte Bolca), and with *P. Goedeli* (Cretaceous, Hakel, Mount Lebanon). In the strength of this caudal squamation the Brazilian fish is intermediate between the two last-mentioned species, but in the shape of its caudal fin resembles most closely *P. Goedeli*.

Palæobalistum flabellatum was discovered in "the southern centre of the Province of Sergipe del Rey."

APOCOPODON SERICEUS, Cope. (Pl. VII, Figs. 4, 4*a*, 4*b*, 5, 5*a*.)

1886. *Apocopodon sericeus*, E. D. Cope: Proc. Amer. Phil. Soc., vol. xxiii, p. 2.

I have already remarked[2] that the dentition named *Apocopodon* is intermediate between that of the typical Myliobatidæ and that of the

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[1] In the British Museum Catalogue of Fossil Fishes, pt. iii (1895), scales are said to be confined to the anterior half of the trunk in *P. orbiculatum*; but an example of this species acquired by the British Museum since 1895 shows numerous very delicate ribs of scales in the caudal region. (B.M. No. P. 9830, described and figured by Heckel: Denkschr. k. Akad. Wiss. Wien, math.-naturw. Cl., vol. xi, p. 229, pl. x.)

[2] Proc. Geol. Assoc., vol. x (1888), p. 297.

Cretaceous *Ptychodus*. The teeth are well described by Cope, but the illustrations of them now given are needed for the satisfactory understanding of their characters. The lateral ends of the median teeth (Fig. 4) are as irregular in their bevelling and truncation as those of *Ptychodus*; and the shape of the side-teeth (Fig. 5) must doubtless have been equally irregular. The appearance of the vasodentine is remarkably similar to that of *Ptychodus*; and the enamelled surface of the flattened crown bears wrinkling (Fig. 4*b*) suggestive of that round the borders of the teeth of *Ptychodus*, but all the wrinkles are directed antero-posteriorly, and there is no transversely ridged central area. As described by Cope, the root is sharply constricted from the crown (Figs. 4*a*, 5*a*), and it differs from that of the teeth of *Ptychodus* in being very slightly marked on its lower face (Fig. 5) with a few broad antero-posterior grooves. There is evidence of at least three paired lateral series of teeth, which rapidly diminish in size outwards.

Apocopodon sericeus occurs in the Cretaceous of Maria Farinha, Province of Pernambuco.

RHINOPTERA PRISCA, sp. nov. (Pl. VII, Figs. 6, 6*a*, 7, 7*a*.)

Vertebræ from the Chalk of Aix and Maastricht are supposed by Hasse to be referable to *Rhinoptera*, but no teeth of this large skate have hitherto been recorded from Cretaceous formations. Two fragments of dentition, apparently of *Rhinoptera*, from the yellow limestone of Maria Farinha, are therefore of much interest.

The most important of these two specimens is shown from the oral aspect, of the natural size, in Fig. 6, and comprises two median teeth, with remains of four paired lateral series. All the teeth are bevelled at the ends in the usual manner, and their coronal surface is flattened or very slightly convex. The superficial layer of the crown has been accidentally removed from all the teeth except one in the outermost row, where it is shown to have been roughened by a fine network of wrinkles (Fig. 6*a*). The root of each tooth is traversed by the usual antero-posterior grooves, but, as well shown in a second example of a median tooth (Figs. 7, 7*a*), these grooves are comparatively few with relatively large intervening ridges. The median teeth preserved are nearly three times as broad as long; the teeth of the first paired series are about twice as broad as long; those of the second paired series are irregular rhombs as broad as long; while the teeth of the two outer paired series are comparatively small, narrow, and antero-posteriorly elongated. The antero-posterior measurement of each tooth preserved is from 7 to 8 mm., and the width of each tooth is as follows:—median, 22 mm.; 1st lateral, 15 mm.; 2nd lateral, 8 mm.; 3rd lateral, 6 mm.; 4th lateral, 5 mm.

R. prisca is readily distinguished from the oldest species of *Rhinoptera* hitherto described, namely, *R. Daviesi*, from the London Clay of Sheppey,[1] by the flatness of the coronal surface of all the teeth, and by the relative proportions of the lateral teeth. It agrees with this species, however, and differs from all others, in the peculiar reticulating wrinkles on the coronal surface of the teeth. These wrinkles are not mentioned in the original description of *R. Daviesi*, but are well seen on some of the teeth of the type-specimen in the British Museum.

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[1] A. S. Woodward: Cat. Foss. Fishes Brit. Mus., pt. i (1889), p. 126, pl. iii, fig. 6.

LAMNA SERRA, A. S. Woodward. (Pl. VII, Figs. 8, 8*a*, 8*b*, 9, 9*a*, 10, 10*a*.)

1889. *Lamna serra*, A. S. Woodward: Cat. Foss. Fishes Brit. Mus., pt. i, p. 400.
1894. *Lamna serra*, A. S. Woodward: Proc. Geol. Assoc., vol. xiii, p. 198, pl. vi, figs. 11, 12.
1898. *Lamna serra*, F. Priem: Bull. Soc. géol. France [3], vol. xxvi, p. 399, pl. x, figs. 1–5.

Several teeth from Maria Farinha are identifiable with *Lamna serra*, which has hitherto been found only in the Upper Cretaceous (Lower Montian) of Mont Aimé, Marne, France. The dental crown is much compressed, with both faces quite smooth, and the lateral denticles are usually in two pairs. The root is short, not bulging much inwards, while its nutritive foramen is situated in a groove. A typical lateral tooth is shown in Figs. 8, 8*a*, 8*b*, bearing not only two pairs of lateral denticles, but also an additional minute denticle posteriorly. A hinder tooth (Figs. 9, 9*a*) also has three denticles posteriorly, but only one broad denticle in front. A comparatively large anterior tooth (Figs. 10, 10*a*) has the outer lateral denticle reduced to a minute point. All these variations are observable in the British Museum collection of teeth of *Lamna serra* from Mont Aimé itself.

LAMNA APPENDICULATA, Agassiz. (Pl. VII, Figs. 11, 11*a*, 12, 12*a*.)

Three teeth from Maria Farinha agree well with those of *Lamna appendiculata*, but those from the front of the jaw (Figs. 11, 11*a*) exhibit unusually small lateral denticles.

SCAPANORHYNCHUS SUBULATUS, Agassiz, sp.

Several small teeth from Maria Farinha belong either to this or a closely allied species. Similar teeth are found with *Lamna serra* in the Chalk of Mont Aimé.

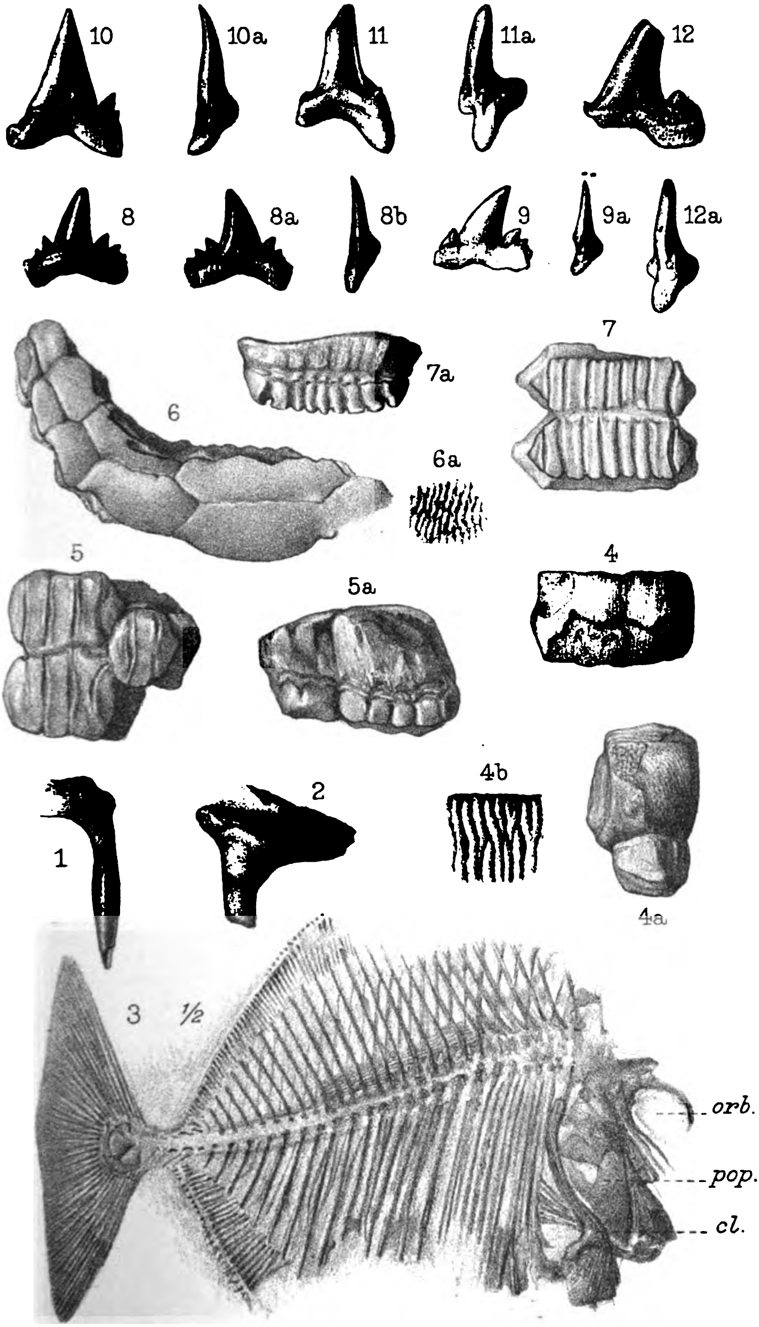
CORAX PRISTODONTUS, Agassiz.

Large typical teeth from Maria Farinha represent this species, as already noted by Cope.

The fish-fauna now described evidently represents the latest part of the Cretaceous period, and is of special interest as affording the earliest known evidence of Myliobatid skates. The occurrence of *Lamna serra*, which is found with *Palæobalistum* in Northern France, is also remarkable.

EXPLANATION OF PLATE VII.

FIG. 1.—*Enchodus subæquilateralis*, Cope. Right palatine, outer aspect.
,, 2.—Ditto. Right palatine, inner aspect, showing ethmoid articulation.
,, 3.—*Palæobalistum flabellatum*, Cope, sp. Imperfect fish, one-half nat. size. *cl.* clavicle; *orb.* orbit; *pop.* preoperculum.
,, 4.—*Apocopodon sericeus*, Cope. Median tooth, coronal and (4*a*) lateral aspects, with part of superficial ganodentine much enlarged (4*b*).
,, 5.—Ditto. First and second lateral teeth, inferior and (5*a*) anterior aspects.
,, 6.—*Rhinoptera prisca*, sp. nov. Portion of dentition, with part of superficial ganodentine much enlarged (6*a*).
,, 7.—Ditto. Two median teeth, inferior and (7*a*) anterior aspects.



G.M.Woodward del.et lith. West, Newman imp.

Upper Cretaceous Fish-remains from Brazil.

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FIG. 8.—*Lamna serra*, A. S. Woodw. Lateral tooth, inner, (8*a*) outer, and (8*b*) lateral aspects.

,, 9.—Ditto. Lateral tooth, inner and (9*a*) lateral aspects.

,, 10.—Ditto. Anterior tooth, outer and (10*a*) lateral aspects.

,, 11.—*Lamna appendiculata*, Agass. Anterior tooth, outer and (11*a*) lateral aspects.

,, 12.—Ditto. Outer and (12*a*) lateral aspects.

Except Figs. 3, 4*b*, 6*a*, all the drawings are of the natural size. The original of Fig. 3 was obtained from the Province of Sergipe del Rey; all the other specimens from Maria Farinha, Province of Pernambuco. All specimens in the National Museum, Rio de Janeiro.

II.—THE CHARLESTON EARTHQUAKE OF AUGUST 31ST, 1886, IN A NEW LIGHT.

By WILLIAM HERBERT HOBBS,
Professor of Geology in the University of Michigan, and Secretary to the Committee of Seismology of the American Association for the Advancement of Science.

(WITH A MAP.)

WITH few exceptions, surface dislocations within the earth's crust or 'earthquake-faults,' have been described in connection with all earthquakes of large proportions.[1] The Charleston earthquake of August 31st, 1886, stands out in some contrast with most others in this particular, and it is further in contrast with some other earthquakes for the reason that the phenomena recorded in connection with it have not as yet been brought into any relation with the structural geology of the district. A partial explanation of this may perhaps be found in the fact that the area most disturbed—the so-called 'epicentral tract'—is entirely included within the coastal plain of the South-Eastern United States. Upon this plain the basement of rock is covered to very considerable depths by unconsolidated material, and it would perhaps be too much to expect that displacements upon fracture planes in the rock would be revealed in full measure at the surface.

There is good reason to suppose that, in consequence of the easily adjustable nature of the coast deposits, considerable displacements upon fracture planes in the rock basement would at the surface of the ground be represented only by 'ploughshare' effects, opened fissures, and lines of 'craterlets,' the latter due to the rapid expulsion of water at points along the fissures. As shown by the extensive report of Major Dutton,[2] all these phenomena appear to have been developed, thousands of fissures of variable but generally small dimensions having been opened throughout an area for about 600 square miles, while the craterlets were perhaps as large and as numerous as in the case of any other earthquake that has been described. It was further observed that the surface of the ground was in places thrown into a series of ridges and valleys, and that where these furrows cross the railway right-of-way the embankments exhibited changes of the same nature.

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[1] For a list of such dislocations formed in connection with the better known earthquakes, see Gerland's "Beitraege zur Geophysik," vol. viii (1907), pp. 236–253.

[2] C. E. Dutton, "The Charleston Earthquake of August 31st, 1886": 9th Ann. Rep. U.S. Geol. Surv., 1890, pp. 203–528.

As we have elsewhere pointed out,[1] active craterlets formed in connection with earthquakes, like the fissure springs of which they are the ephemeral and much overgrown representatives, appear to be arranged upon fracture planes, and are located, in many cases at least, at the intersections of such planes. If, therefore, we can secure a correct map of the craterlets within an earthquake district, this map should reveal the outlines, at least, of the fracture system within the province. Notwithstanding the fact that an alignment of craterlets along earthquake-faults and fissures has been often pointed out, it has not generally been thought important to accurately locate them. The unique exception is, perhaps, the map prepared by Major Dutton and printed in connection with his report upon the Charleston earthquake.[2]

A mere glance at the map in question (reproduced with some additional lines on p. 199) discloses the fact that the areas conspicuous for craterlets are aligned within zones strongly marked out in at least a number of instances. Perhaps the most striking examples are to be observed within the area to the south and southwest of the station of Woodstock, where the lines trend north-easterly. Throughout the district affected, however, similar if less striking alignments are to be observed. Such lines mark out lanes of maximum disturbance at the surface, and through them we are enabled to study the distribution of surface intensity of shocks in connection with the Charleston earthquake.

We are in this instance, further, especially fortunate in having another excellent guide to the surface distribution of seismic intensity, and one the full significance of which seems to have been overlooked. The 'epicentral tract' is crossed by three radiating lines of railway which afford well-distributed sections along which location is especially accurate. Grading the intensity of the shocks is furthermore facilitated along the line of the railways for the reason that a structure of essentially uniform elasticity and rigidity extends throughout the sections. The examination of the tracks to collect the evidence upon the distribution of damage was made by Mr. Earle Sloan, apparently a very careful observer. The report shows that sometimes for miles within the 'epicentral tract' the tracks reveal little, if any, serious damage, but such areas of little disturbance are succeeded by relatively narrow zones within which fish-plates are torn out, joints opened, and in a very considerable number of instances the tracks are thrown into a local 'kink' or S-shaped distortion. No simple law was found to determine the intervals between successive points of such maximum derangement to the track, but Major Dutton has drawn the conclusion that upon each railway line the distribution of damage indicates a central maximum from which the intensity falls away upon either side by a law expressed in a very simple reversed curve whose form resembles the Hogarthian line of beauty, and has been named by him an indicator.

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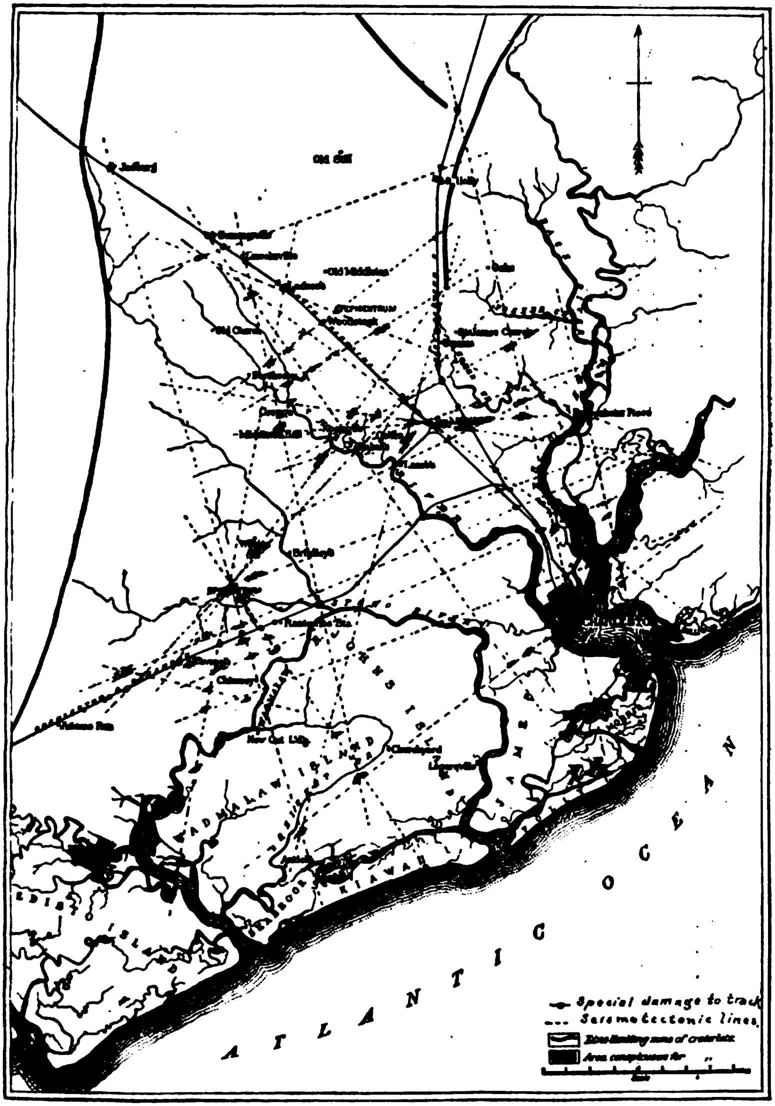
[1] W. H. Hobbs, "Topographic Features formed at the time of Earthquakes, and on the Origin of the Mounds in the Gulf Plain": Amer. Journ. Sci., 4th ser., vol. xxiii (1907), pp. 245–256.

[2] Loc. cit., pl. xxviii.



Map of area of the Charleston Earthquake of August 31st, 1886.

To the present writer the data given failed to support the view of a gradation in intensity away from any central maximum; but indicate rather many strictly local maxima where the track has been severely wrenched, separated from each other by relatively large distances of damaged minima. In the following lists we have summarized from the report[1] the data collected from the damage observed by Mr. Sloan along each of the three railroads which cross the district.

South Carolina Railway.

Miles.[2]
3¾. Rails bent and large displacements. Joints opened.
5. Fish-plates torn and joints opened.
6. Joints opened and bed depressed 6 inches.
9. Serious flexure of the track. Train derailed.
10. Ten Mile Hill station. Most marked development of craterlets. Severe distortion of track where branch road to Lamb's leaves main track.
10¾. Another severe flexure of track. Track driven longitudinally to the south-eastward so as to form double or S-shaped curve.
11. Track parted longitudinally with gaps of 7 inches between rail ends. Depression of 18 inches for length of 60 feet.
11½. Opening of joints by as much as 7 inches. (From 11½ to 15½ miles no sharp kinks.) A little beyond Ladson's. Tracks sharply flexed with double curvature.
18½. Another severe flexure.
19¾. Still more complex flexure, and 500 feet further a kink in the track.
20. Many serious flexures.
21. Track distorted vertically and horizontally.
21¾. Summerville, numerous sharp flexures. (For next six miles little disturbance.)
27½. Jedburgh, severe buckling of track.

North-Eastern Railway.

1½. Lateral flexure of rather large radius. Large track of soft ground moved bodily.
4. Track makes slight curve. Noteworthy distortion.
6. 400 feet of track depressed with a maximum of 22 inches.
7. Track depressed over culvert, etc.
8. Slight flexure.
$8\frac{2}{10}$. Embankment 16 feet high depressed 10 inches with indication of forcible vertical wrench.
9. (Approximately.) Whole superstructure shifted 4 inches to the eastward.
9⅛. Craterlets which ejected sand 13 feet high.
9½. Fish-plates broken and rails parted 8½ inches.
9¾. Superstructure shifted to eastward.

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[1] Loc. cit., pp. 282–306.
[2] All distances are from the Charleston terminus.

Miles.
10. Most important displacement. Embankment 15 feet high was pushed 4½ feet eastward and kink produced in track.
10⅛. Wing wall of culvert broken. Embankment depressed.
11⅜. Much vertical movement. Trestle damaged.
12. Another great disturbance. Fish-plates broken and joints opened. Cracks running N. 40° E. crossed track, "developing into a series or network of cracks throughout a belt 150 feet wide and 700 feet long."
12⅝. Culvert collapsed.
13¼. Brick club house destroyed.
15¼. Goose Creek. South end of trestle deflected eastward, and north end to westward.

Charleston and Savannah Railway.

The tracks of this road are those used by the North-Western for some miles out from the Charleston station. From the point of departure no serious damage to the track was found to the east of the Ashley River.

Miles.
11⅜. Ashley River. River banks had been brought nearer together. Drawbridge jammed. West of river the joints of rails were opened.
16⅝. Rantowle's Bridge. Drawbridge shifted. Banks brought nearer together.
18. Rantowle's Station. Track sharply kinked into double fracture. Embankment depressed two feet.
18$\frac{2}{10}$. Embankment showed a depression of one foot.
20$\frac{7}{10}$. A maximum of lateral displacement.
22$\frac{7}{10}$. Here serious flexures which stopped abruptly.
25$\frac{1}{10}$. Roadbed depressed six inches.
25$\frac{2}{10}$. 300 feet of track depressed 1½ feet.
26. Sinuous flexures in track.

Upon the map printed with Dutton's report to show the arrangement of craterlets within the 'epicentral track,' we have carefully plotted the data contained in the above lists (see Map, p. 199). Before these data had been plotted, however, lines had been drawn to join the areas of craterlets, and these lines extended. As soon now as the loci of special damage to the tracks had been plotted, it was seen that these points lie where the narrow zones of craterlets extended and intersect the railway tracks. In consideration of the exactness with which these correspondences occurred, there seems to be no reason to doubt (1) that the lines of craterlets extended are the projections upon the surface of the ground of the fracture planes within the rocky basement upon which differential movement occurred at the time of the earthquake; (2) that the areas of craterlets shown upon the map correspond in the main to projections of the intersections of such earthquake-faults; and (3) that the faults are arranged in essentially parallel series, of which two series are more conspicuous than the others. Their prevailing directions are about N. 65° E. and N. 10° W.

The data compiled in the report are susceptible of more elaborate analysis than has here been attempted, since we have sought only the points of local wrenching of the tracks. As in the case of most earthquakes, the observations show abundant evidence that large blocks of the crust have been shifted laterally and vertically, with lesser adjustments of their component parts. When within the area covered by railway tracks, these adjustments may be measured by those displacements of the right-of-way which are indicated by lateral displacements between points of special wrenching. The Charleston earthquake, in the light of the established relationships, is brought into harmony with the greater number of large earthquakes which have been carefully studied in recent times.

III.—NOTES ON THE OSTEOLOGY OF *OPHTHALMOSAURUS ICENICUS*, SEELEY, AN ICHTHYOSAURIAN REPTILE FROM THE OXFORD CLAY OF PETERBOROUGH.

By C. W. ANDREWS, D.Sc., F.R.S., British Museum (Natural History).

DURING the last few months the preparation of a descriptive catalogue of the magnificent collection of reptilian remains obtained by Mr. A. N. Leeds in the Oxford Clay of Peterborough, has rendered it necessary to examine in some detail the fine series of more or less complete skeletons of *Ophthalmosaurus* preserved in the British Museum. In the course of this examination a certain number of new facts have come to light, and since it will be some time before the detailed description can appear it seems desirable to give a brief account of some of the more interesting points.

Comparison of a number of these skeletons with one another shows that an extraordinary degree of variability in the form of many of the bones occurred, the differences in the shape of certain elements, such as the quadrates or the basi-occipitals, being so great in different skeletons that if these bones were found isolated they would almost certainly be referred to different species. Further examination shows that this would not be justifiable, since two skeletons of which the quadrates differ may have precisely similar basi-occipitals, or *vice versâ*, the same thing holding good in the case of other parts. In fact, if any one part of the skeleton were taken as the standard of comparison, five or six species might be established which would not coincide with those that would be formed if another part were employed in diagnosis. These variations are partly real and partly apparent. The real differences seem to be the result of the persistence of a large amount of cartilage in the skeleton of these marine reptiles, the consequence of this being that the actual form of the bones depends largely on the extent to which ossification had proceeded, and in any case is less definite than in land animals. The apparent differences are due to the pressure to which the bones have been subjected. This often leads to deformation without any actual fracture being visible, and is particularly noticeable in the case of the vertebræ, the centra of which may be shortened by nearly half their length without any other distortion. For the above-mentioned reasons it has therefore seemed best to refer all the specimens to the species

Ophthalmosaurus icenicus described in 1874 by Professor Seeley[1] from a shoulder-girdle and fore-paddle included in the Leeds Collection.

Recently a number of papers have been published by Knight,[2] Gilmore,[3] and others on the skeleton of the American Ichthyosaur *Baptanodon*, a contemporary of the English *Ophthalmosaurus*, from which indeed there seems no real reason for separating it, although the above-mentioned writers are not of this opinion.

The restored figure (Fig. 1) of the skull shows that one of the most notable characters is the immense relative size of the orbits, which occupy practically all the lateral aspect of the posterior region, the bones behind and below them (postorbitals, jugal, quadratojugals) forming only a narrow band. Another peculiar feature is the presence, on the anterior part of the jaws only, of small, loosely attached teeth, which in many specimens are not found, though whether teeth were actually altogether wanting in adult animals or whether they have been lost after death is uncertain.

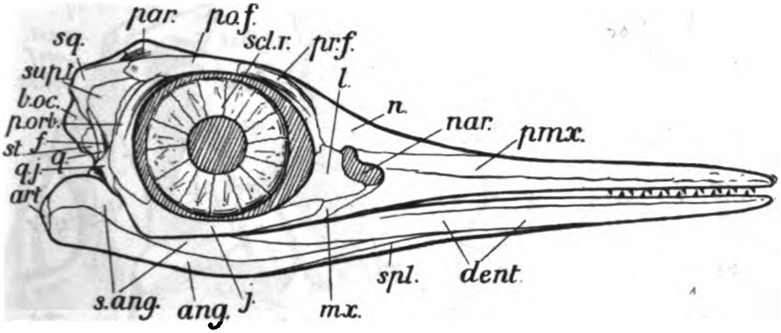

FIG. 1.—*Ophthalmosaurus icenicus*, Seeley. Restored skull from right side. About ⅙ nat. size.

ang. angular; *art.* articular; *b.oc.* basi-occipital; *dent.* dentary; *f.* foramen between quadrate and quadratojugal; *j.* jugal; *l.* lachrymal; *mx.* maxilla; *n.* nasal; *nar.* external nares; *par.* parietal; *pmx.* premaxilla; *po.f.* postfrontal; *p.orb.* postorbital; *pr.f.* prefrontal; *q.* quadrate; *q.j.* quadratojugal; *s.ang.* surangular; *scl.r.* sclerotic ring; *spl.* splenial; *sq.* squamosal; *st.* stapes; *sup.t.* supratemporal.

In some of the specimens the condition of the bones forming the posterior surface of the skull has made it possible to attempt a restoration of this region, of which a number of more or less inaccurate figures, mostly from skulls of *Ichthyosaurus*, have been published. Fig. 2 shows the relation of most of the bones of this region to one another; the pro-otic has been omitted because its position is doubtful, and the parietal also is not drawn. It will be noticed that the whole arrangement seems to be designed to impart the maximum possible degree of rigidity to the quadrates. The stapes (*st.*), which, as usual in the group, have lost their auditory function, unite firmly with the basi-occipital by their expanded inner ends, while their outer extremities fit into pit-like facets of the quadrates; below they lie in a groove on the upper surface of the pterygoids (*pt.*), the postero-external wings of which also unite firmly with the inner surface of the quadrates. These bones are further supported above by the squamosals (*q.b.sq.*), which closely embrace their upper ends and send down their inner faces processes which overlap the ascending processes of the pterygoids. The squamosals themselves are further supported by the outer ends of the opisthotics (*op.*), which internally rest upon the basi-occipital and the exoccipitals. The supra-occipital (*soc.*) consists of a lateral epiotic region, which is impressed by two of the semicircular canals, and a posterior occipital region, which is perforated on either side of the middle line by a large foramen (*for.*), which may have transmitted a blood-vessel or may possibly have something to do with the peculiarly modified auditory apparatus, and have served for the passage of an enlarged *ductus endolymphaticus.*

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[1] Quart. Journ. Geol. Soc., vol. xxx (1874), p. 696, pls. xlv, xlvi.

[2] Amer. Journ. Sci. (4), vol. xvi (1903), p. 76.

[3] Memoirs Carnegie Museum, vol. ii (1905), pp. 77, 325.

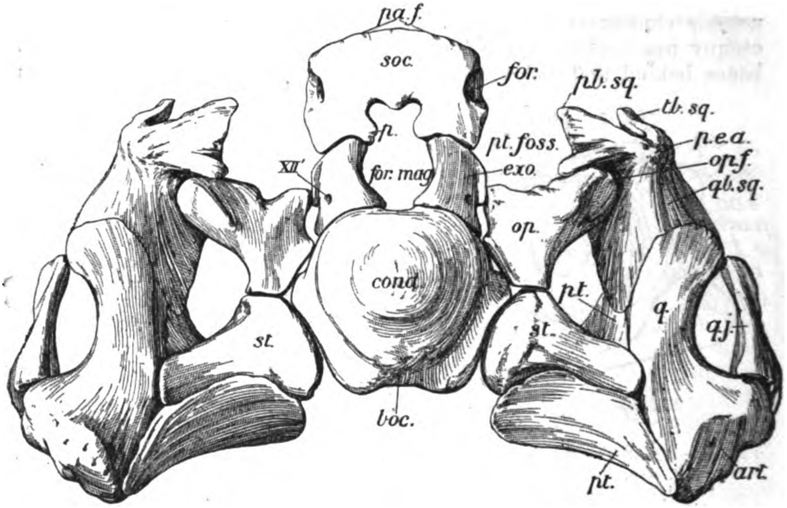

FIG. 2.—*Ophthalmosaurus icenicus*, Seeley. Reconstruction of the posterior surface of skull. About ⅓ nat. size.

art. articular surface of quadrate; *boc.* basi-occipital; *cond.* occipital condyle; *exo.* exoccipital; *for.* foramen in supra-occipital; *for. mag.* foramen magnum; *op.* opisthotic; *op.f.* facet for opisthotic; *p.* process of supra-occipital projecting into foramen magnum; *pa.f.* facet for parietal; *p.b.sq.* parietal branch of squamosal; *p.e.a.* postero-external angle of squamosal; *pt.* pterygoid; *pt.foss.* post-temporal fossa; *q.* quadrate; *q.b.sq.* quadrate branch of squamosal; *q.j.* quadratojugal; *soc.* supra-occipital; *st.* stapes; *t.b.sq.* temporal branch of squamosal; XII, foramen for posterior branch of the hypoglossal nerve.

The other parts of the skull do not present any peculiarities of sufficient importance to be noticed here. The sclerotic ring consists of about fourteen plates, which are united by suture and bend round on to the posterior surface of the eyeball, as was pointed out by Owen[1] in *Ichthyosaurus* and recently by Gilmore[2] in *Baptanodon.*

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[1] Foss. Rept. Liassic Form., pt. iii (Mon. Pal. Soc., 1881), p. 103

[2] Mem. Carnegie Museum, vol. ii (1906), p. 328.

The vertebral column consisted of about 122 vertebræ. The centra of the atlas and axis are closely fused, and only in very young individuals are any clear indications of their original separation to be observed. Behind these are about thirty-eight vertebræ, which may be regarded as precaudal; these bear both parapophyses and diapophyses for the articulation of the ribs; these processes when followed from before backwards are found to descend on the side of the centra and approach till they finally unite on about the forty-first vertebra, which may be regarded as the first caudal; in a few cases this union may take place on one side one or two vertebræ further forward than on the other, there being two facets on one side and one on the other in these centra. The caudals are about eighty-two in number; they bear single rib facets till just in front of the point where the column bends down into the caudal fin, and it appears that chevrons also were present in this region. A little in front of the bend above referred to the centra diminish very rapidly in size; they are also less definite in form and have rounded edges, probably because more flexion took place at this point than elsewhere. The bend itself is caused by the presence of five or six centra which are more or less wedge-shaped, being longer dorsally than ventrally. Behind the bend there may be as many as forty-eight vertebræ, the centra of which

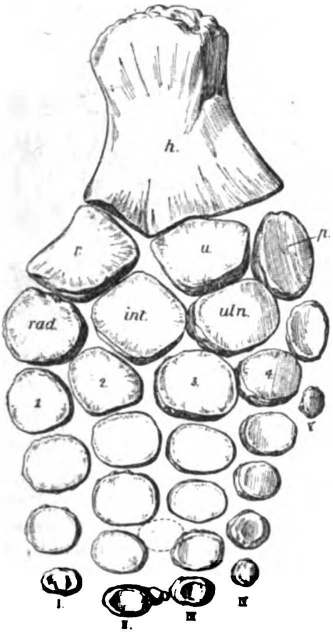

FIG. 3.—*Ophthalmosaurus icenicus*, Seeley. Ventral surface of right fore-limb. About ⅙ nat. size.

h. humerus; *int.* intermedium; *p.* pisiform; *r.* radius; *rad.* radiale; *u.* ulna; *uln.* ulnare; 1–4, distal row of carpals; I–V, the five digits.

are well ossified with sharply defined edges. The neural arches seem to have persisted to the extreme end of the tail, and there may have been very small chevrons also.

The neural arches of some of the anterior cervical vertebræ consist of two lateral pieces, and in this case the anterior and posterior zygapophyses are paired. Further back the arch shows no trace of division into halves and the anterior and posterior zygapophyses unite form single median facets.

The precaudal ribs are double-headed, their capitular and tubercular process being comparatively long. The body of the ribs is grooved longitudinally on its anterior and posterior surfaces, which must have added considerably to their rigidity. Only fragments of slender ventral ribs have been found.

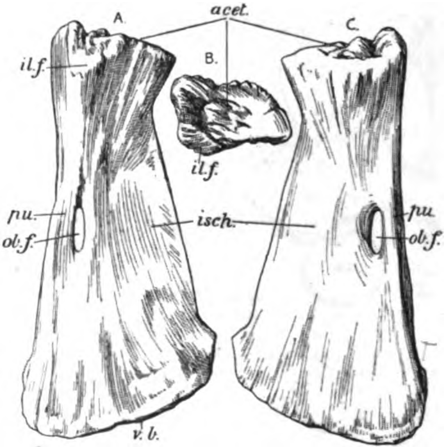

FIG. 4.—*Ophthalmosaurus icenicus*, Seeley. Right ischio-pubic bone. A, upper (visceral) surface; B, proximal articular end; C, ventral (outer) surface. About ⅓ nat. size.

acet. acetabular surface; *il.f.* facet for ilium; *isch.* ischium; *ob.f.* obturator foramen: *pu.* pubis; *v.b.* ventral border.

The shoulder-girdle has been described and figured by Professor Seeley.[1] The coracoids are broad plates of bone, greatly thickened in their middle portion. Their posterior border is convex, while the anterior is concave owing to the presence of a wide, sharply defined notch. Internally the coracoids united with one another in a large cartilaginous symphysis; externally they bear a short anterior facet for union with the scapula and a much larger posterior cartilage-covered surface for the humerus. The scapula consists of a narrow dorsal blade and an expanded and thickened ventral region, which bears a facet for union with the coracoid, and behind this a small surface which completed the glenoid cavity in front. On the anterior border of the scapulæ is a roughened surface marking the line of union with the outer end of the clavicles. These are strongly curved bones, terminating externally in a point and uniting with one another in the middle line by an irregularly interdigitating suture, which may have been obliterated in advanced life. The upper surface of the middle portion of the clavicular arch is deeply channelled for the reception of the anterior bar of the T-shaped interclavicle, the posterior process of which extends back beneath the coracoid symphysis.

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[1] Quart. Journ. Geol. Soc., vol. xxx (1874), p. 696, pls. xlv, xlvi; also Proc. Roy. Soc., vol. liv (1893), p. 151, fig. 1.

The fore-limb (Fig. 3, p. 205) is much larger than the hind, and forms a wide and powerful paddle. The humerus (*h.*) is a short and very stout bone, the distal end of which is expanded, and articulates with the radius (*r.*), ulna (*u.*), and to a varying degree with a postaxial element, usually regarded as the pisiform (*p.*). The proximal row of carpals consists of the radiale (*rad.*), the intermedium (*int.*), and the ulnare (*uln.*). There are five digits (I–V), the postaxial one borne by the pisiform being much reduced. The paddle bones do not form a close mosaic as in most Ichthyosaurs, but seem to have been separated by a considerable amount of cartilage throughout life.

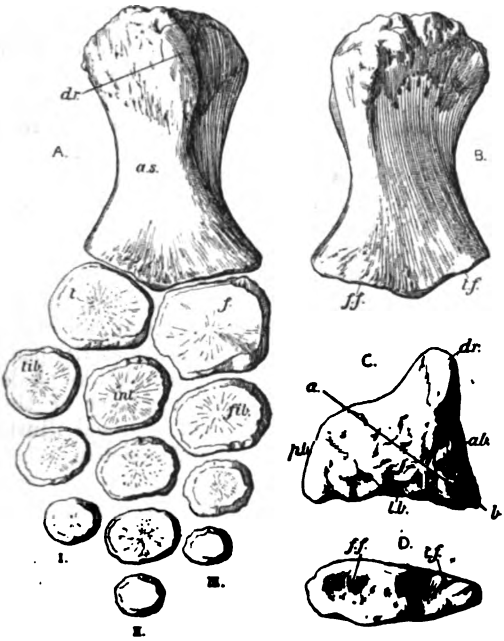


FIG. 5.—*Ophthalmosaurus icenicus*, Seeley. Left hind-limb. A, dorsal surface of paddle; B, ventral surface of femur; C, proximal end of femur; D, distal end of femur. About ⅓ nat. size.

a.b. anterior border of proximal end of femur; *a.s.* anterior surface of femur; *d.r.* dorsal ridge of femur; *f.* fibula; *f.f.* facet for fibula; *fib.* fibulare; *int.* intermedium; *l.b.* lower border of proximal end of femur; *p.b.* posterior border of ditto; *t.* tibia; *t.f.* facet for tibia; *tib.* tibiale; I–III, the three digits. In figure C the line *a–b* marks the direction of the long axis of the distal end of the bone in relation to the proximal end.

The pelvis and hind-limb are small and evidently undergoing reduction. The ilium is a sickle-shaped bone, thin above, but thickening towards its ventral end, where it bears two articular surfaces, one forming part of the acetabulum, the other uniting with the ischio-pubis; probably all connection with the vertebral column was lost. The pubis and ischium (Fig. 4) are fused with one another at their upper and lower ends, the line of separation being marked by a slit-like foramen (*ob.f.*) and sometimes by a notch in the ventral border. At the thickened upper ends of the combined bones there are two roughened surfaces, the smaller (*il.f.*) for union with the ilium, the larger (*acet.*) forming the greater part of the acetabulum; the two bones are so closely united at the upper end that even in very young examples it is impossible to determine what share in the formation of these facets is taken by each. Distally the bones are thin, and there is no clear indication that the opposite sides met in a median symphysis.

The femur (Fig. 5), though much smaller than the humerus, is on the whole very similar in form to that bone, with the important exception that it unites distally with two elements only, the tibia (*t.*) and fibula (*f.*). Of these the fibula is the larger, at least except in some cases in which the thin anterior edge of the tibia is fully ossified. The proximal row of carpals are three in number, the tibiale (*tib.*), intermedium (*int.*), and fibulare (*fib.*); the distal row also consists of three only, while the remainder of the tridactyl (I–III) paddle consists only of irregularly-shaped metatarsals and nodule-like phalanges.

The above account is merely a brief summary of the complete description which will be given in the Catalogue and illustrated with figures of most of the bones of the skull and skeleton.

IV.—SEDGWICK MUSEUM NOTES.

NEW FOSSILS FROM HAVERFORDWEST.—VII.

By F. R. COWPER REED, M.A., F.G.S.

(PLATE VI.)

SLADINA CATENIFORMIS, gen. et sp. nov. (Pl. VI, Figs. 1–7*a*, ? 8–9*a*.)

IN the Slade Beds of Upper Slade there occur small flattened leaf-like bodies generally fused together in a linear series of 2–4, but sometimes singly. These fossils have a somewhat puzzling aspect, but they may be referred without any doubt to the Bryozoa, though to a new and undescribed genus and species.

Diagnosis.—Zoarium composed of a single linear row of leaf-like segments, each of which is usually lanceolate in shape, thin, flattened, and tapering anteriorly. The segments are generally graduated in size, and each is fused by its apex to the base of the one preceding it, but the terminal one, which is the smallest and narrowest of the series, ends freely in a point, and possesses a perfect lanceolate form. Each leaf is bilaterally symmetrical and unilaminar; the reverse face is slightly convex, ridged axially, and covered with a thin epitheca bearing a median longitudinal midrib continuous from leaf to leaf throughout the whole series in the zoarium; on each side of the midrib are rather strong arched longitudinal striæ, indicating by their pointed lanceolate arrangement and invasion of the base of the preceding segment that the leaves overlap each other successively. There is occasionally a short stalk present in the basal and apical segments (and paired lateral spines may be present). The celluliferous face of each segment is flat and shows the one layer of cells arranged in rather irregular rows diverging in a fan-shaped manner from the base; the median rows are more or less subparallel and continuous from leaf to leaf without a break, and are composed of short cells of equal size, very oblique to the surface; the lateral rows diverge more strongly to the sides and are irregular, and the cells are subequal in size, somewhat larger, shorter, and less oblique to the surface, so as to form a close polygonal mosaic; in a leaf 5 mm. long, 15–20 cells may be counted round each lateral margin, and 10–15 across the widest part of the leaf, the number varying with the size of the leaf, but the size of the cells remains fairly constant.

Dimensions:

I.		Length.	Width.
Basal leaf		4·75	3·00 mm.
Middle		4·00	2·75 mm.
Apical		? 3·00	1·50 mm.
II.			
Basal leaf (showing transverse constriction or compound nature)	(posterior part)	2·50	2·75 mm.
	(anterior part)	4·00	3·00 mm.
Middle leaf		3·75	2·75 mm.
Apical		2·25	1·25 mm.
III.			
Posterior leaf		5·25	4·25 mm.
Anterior		5·25	4·00 mm.

In No. II the basal leaf shows a transverse constriction which may indicate that it is composed of two almost completely fused leaves, or the constriction may be of a secondary nature, which would ultimately result in the division of the one leaf into two and thus increase the number of segments of the zoarium.

Isolated leaves: length, 4·0–5·0 mm.; width, 2·0–2·25 mm.

There are two other specimens (Pl. VI, Figs. 8–9*a*) which probably represent a variety or another and later stage of growth in the same species. One of these consists of a modified leaf of the same type as the foregoing, with the usual medianly ridged epitheca on one side and the radiating rows of cells on the other. But instead of being of a lanceolate shape, it is subrhomboidal and considerably broader than usual; the two longer sides meet at the apex at about 75°, and the two shorter ones at the base at rather more than a right angle; the base is produced into a short point, but the lateral angles are furnished with long straight tapering spines directed at right angles to the axis of the leaf, and marked by a median groove, but apparently not celluliferous. In length they are equal to about two-thirds the greatest width of the leaf. At the apex of the leaf we see attached in the usual way a very small slender lanceolate leaf of about half the length of the main one. Length of large leaf, 5·0 mm.; maximum width of ditto, 4·5 mm.; length of small leaf, 2·25 mm.

The other specimen (Pl. VI, Figs. 9, 9*a*) has a much less regular shape and appears to consist of three segments, all of which may be regarded as modified leaves. The lowest and largest one has an irregular elongated rhomboidal shape, angulated laterally near the base, as in the last described specimen, but not provided with spines; its base is somewhat produced, and its apex is broadly fused with a small lanceolate leaf of the usual type. The point of the latter is attached to the apex of an equilaterally triangular segment, provided at the extremities of its base with short stout grooved straight spines directed forwards, like horns. The whole series of three segments has the usual epitheca and continuous median ridge on one face, and on the other the customary arrangement of cells, which are even similarly developed on the peculiar horned triangular segment. Length of whole series to tip of spines, 15·0 mm.; length of lowest segment, 7·5 mm.; width of ditto, 4·25 mm.; length of second segment, 3·25 mm.; length of triangular segment (without spines), 3 25 mm.

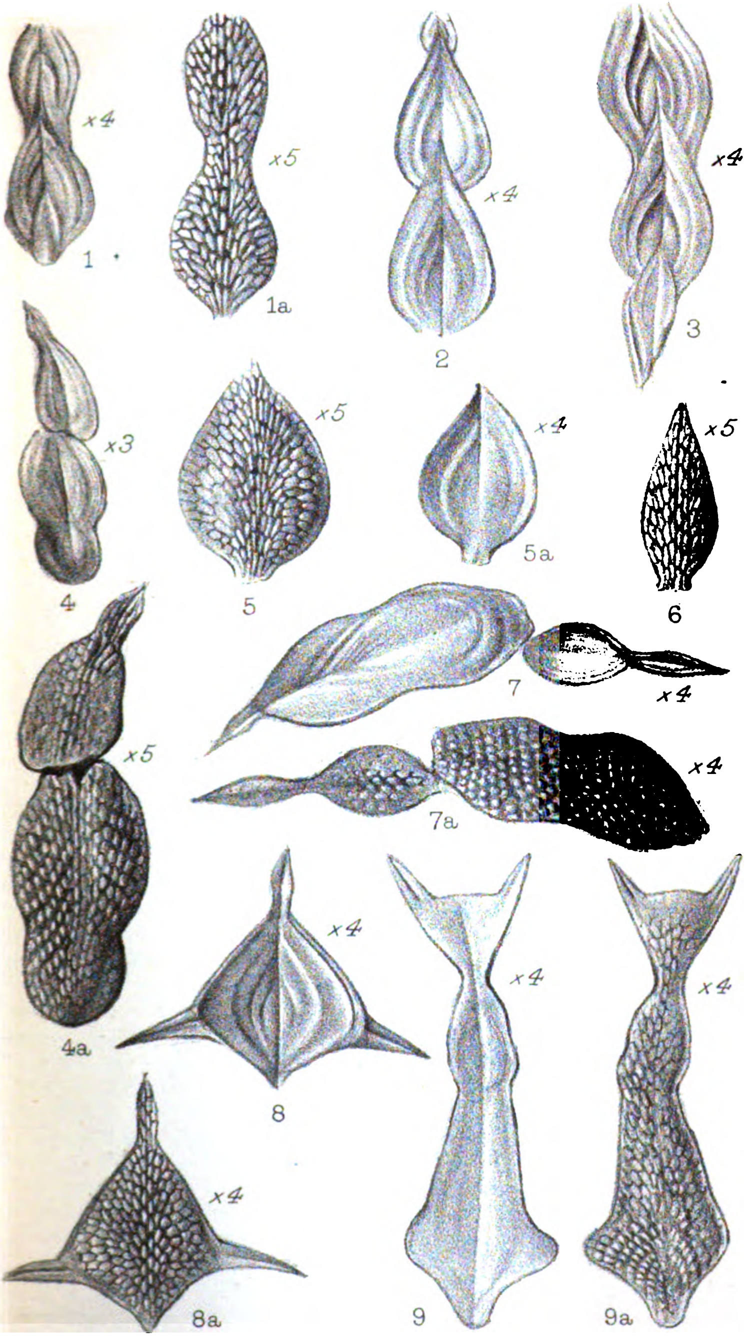
Affinities.—The structure of this peculiar Bryozoan reminds us in some respects of *Ptilodictya*, especially in the arrangement of the zoœcia, but it is unilaminar instead of bifoliate, and we are not sufficiently acquainted with the minute structure of the celluliferous surface or with the internal characters to press this comparison. The unilaminar and segmented nature of the zoarium, the peculiar epitheca, and the occasional presence of spinose processes, with a prevailing bilateral symmetry in all parts, prove that this Slade Bryozoan belongs to a new and distinct genus to which the name *Sladina* may be suitably applied. The chain of lanceolate segments of graduated sizes with the smallest segment at the top suggest apical growth of the zoarium. The multiplication of segments may take place by transverse constriction, if this is the correct interpretation of specimen II and similar ones. Whether the apical segments are naturally detached to form new zoaria or whether their occasional isolated occurrence is accidental must remain an open question for the present.

Definition of genus.—Zoarium unilaminar, composed of flattened lanceolate segments, attached in a straight line, with occasionally the apical one triangular and furnished with spines; the basal one also may be provided with a pair of lateral spines. Each segment is bilaterally symmetrical and is covered on one face by a thin medianly ridged epitheca with growth-lines concentric to lateral margins. Celluliferous face closely set with zoœcia, arranged in 2–3 median rows (which are generally continuous through the whole chain of segments), with irregularly radiating rows of similar cells on each side, diverging in a fan-like manner to the lateral margins of each leaf. Type, *Sladina cateniformis*, Slade Beds, Upper Slade, Haverfordwest.

EXPLANATION OF PLATE VI.

NEW FOSSILS FROM HAVERFORDWEST.

FIG. 1. *Sladina cateniformis*, gen. et sp. nov. Reverse face. × 4.
,, 1*a*. Ditto. Same specimen. Celluliferous face. × 5.
,, 2. Ditto. Reverse face, showing three segments. × 4.
,, 3. Ditto. Reverse face, showing small basal segment. × 4.
,, 4. Ditto. Reverse face, with lowest segment showing transverse constriction. × 3.



G. M. Woodward del. et lith.
West, Newman imp.

New Fossils from Haverfordwest.

Fig. 4*a*.	*Sladina cateniformis*, gen. et sp. nov.	Same specimen. Celluliferous face. × 5.	
,, 5.	Ditto.	Isolated segment. Celluliferous face. × 5.	
,, 5*a*.	Ditto.	Same specimen. Reverse face. × 4.	
,, 6.	Ditto.	Isolated apical segment. Celluliferous face. × 5.	
,, 7.	Ditto.	Reverse face of disjointed specimen. × 4.	
,, 7*a*.	Ditto.	Same specimen. Celluliferous face. × 4.	
,, 8.	Ditto.	Variety or later stage with lateral spines. Reverse face. × 4.	
,, 8*a*.	Ditto.	Same specimen. Celluliferous face. × 4.	
,, 9.	Ditto.	Variety with spined terminal segment. Reverse face. × 4.	
,, 9*a*.	Ditto.	Same specimen. Celluliferous face. × 4.	

V.—RECENT GEOLOGICAL INFORMATION ABOUT BLACKHEATH.

By T. V. HOLMES, F.G.S.

(WITH A MAP.)

A GLANCE at a geological map shows Blackheath and Greenwich Park at the western end of the Lower Tertiary escarpment which is conspicuous on the southern side of the Thames as far eastward as Erith.

This escarpment has the Chalk visible here and there at its base. Above the Chalk comes the Thanet Sand, then the Woolwich Beds, while the plateau is capped by the Blackheath Beds. Around Shooters Hill the London Clay comes on above the Blackheath Beds, and is itself capped at Shooters Hill by gravel of later date. At Blackheath the surface is composed of the Blackheath Pebble Beds. But before mentioning the recent workings there, it is necessary to recall events which took place between twenty-five and thirty years ago on that well-known Common.

On Thursday, April 12th, 1878, after a night of very heavy rain, it was found that at the spot marked A on the map, south of the Shooters Hill Road, and north of that between the south-west corner of Greenwich Park and Morden College, a subsidence had occurred. This, after some little delay, was filled up by the Metropolitan Board of Works. Early in November, 1880, another appeared some distance south-west of the first (B), and on November 19th a third, not far from the first, marked on the map as C. As regards shape, they all agreed in being considerably wider at the bottom than at the top. But that at B was shallower, and widened at the bottom to a greater extent than the two other holes. A and C were almost perfectly identical in shape and depth, and were less than 150 yards apart. Of B I have nothing more to say than that its broader and shallower form suggested a distinction of some kind which made the amount of its affinity to A and C uncertain. In the *Engineer* of February 4th, 1881, sections are given of B and C. The size and shapes of A and C are both described in the account given in the *Engineer* of the last-named pit. It is said to have been almost circular in shape, "being 7 ft. 8 in. in the longest diameter and 6 ft. 9 in. in the shortest. The sides went down vertically to a depth of 18 feet, and had all the appearance of a well or artificial shaft. At the bottom was a heap of fallen earth, and when this was removed the sides were found to recede, the hole increasing in its diameter to about 14 feet."

The Lewisham and Blackheath Scientific Association (a then newly formed local scientific society) raised a fund from residents in the neighbourhood for the exploration of pit C, and appointed a committee to superintend the work.[1] From this committee an executive sub-committee was selected, consisting of Sir G. B. Airy, Dr. H. E. Armstrong, W. H. Bond, E. W. Brabrook, T. V. Holmes, H. W. Jackson, Rev. Brooke Lambert, J. K. Laughton (chairman), J. E. Price, Dr. Prior Purvis, Rev. T. Wiltshire, and John Yeo. The hole was timbered and the work began. At a depth of about 34 feet from the surface water appeared, and became more and more troublesome as the depth increased. From the report drawn up by the Chairman we learn:—

"The ground, which was continuously sand more or less mixed with water-worn rounded stones, varying in size from a marble to a cricket ball, was throughout broken and disturbed; it yielded readily to the spade, and the pickaxe was at no time called into requisition. The earth behind the timber was thus all alive; it had no cohesion of itself, and transmitted the pressure to the timbering almost as if it had been fluid. When the weight and liveliness of the water was added to that of the sand this effect was intensified, and apprehensions began to be entertained lest the timbering should be found of insufficient strength."

At a depth of 43 feet there was an inequality of vertical resistance, which caused the timber framework to 'cant' and 'long-corner.' This tendency increased, and combined with the difficulty arising from the inflow of water to stop further excavation, owing to the great difficulty and expense which would attend it. So it was resolved to drive an iron tube down, to test the hardness or softness of the material, and to ascertain the existence of any cavity. Two tubes were driven down; the first was withdrawn after having sustained a fracture, the second was driven to a depth of 84 ft. 6 in., but was there stopped by some hard mass, which it could neither pierce nor thrust aside. The first pipe was easily drawn up; the second only with the utmost difficulty, though the track of each was almost perfectly identical. As the second was being withdrawn specimens of the earth at the bottom were obtained by means of a small scoop attached to the end of a rod passed down the pipe, and these samples testified to the abnormal condition of the strata passed through.

We read:—"Down to about 50 feet they are sandy; but from that to the bottom are clayey, and more clayey as the depth increases. But a comparison with the known stratification of the district shows that from 35 to 50 feet or thereabouts, is the level of the clayey beds; that below that is the Thanet Sand; and it is therefore conjectured that the fine peculiarly greasy clay brought up by the scoop from the depth of 84 ft. 6 in. may have been washed down when the shaft, no longer used, was suffered to fall in."

Accounts of subsidences in other districts, supposed to be analogous in some way to those at Blackheath, were sent in to the Committee, who also consulted several distinguished geologists, archæologists, and engineers. Professor Prestwich and Mr. W. Whitaker both inclined to think the cause of the subsidences not purely geological, and Mr. F. C. J. Spurrell thought them the result of the existence of deneholes at the spots where they occurred. The Committee, as a body, felt unable to accept any view as conclusive. Being myself a member of the Committee, and having a decided view on the matter, my colleagues were good enough to append my remarks to the report. They were to the effect that no purely natural action of water under Blackheath on the Chalk was at all probable, owing to the presence of the more or less clayey beds of the Woolwich Series, which prevented water percolating through the pebble beds at the surface from ever reaching the Chalk. But that, granting the existence of deep shafts from the surface ending in chambers in the Chalk (like that described by Mr. Flinders Petrie as existing at Eltham), the Blackheath subsidences were easily explained. For a disused and neglected shaft would naturally become more and more

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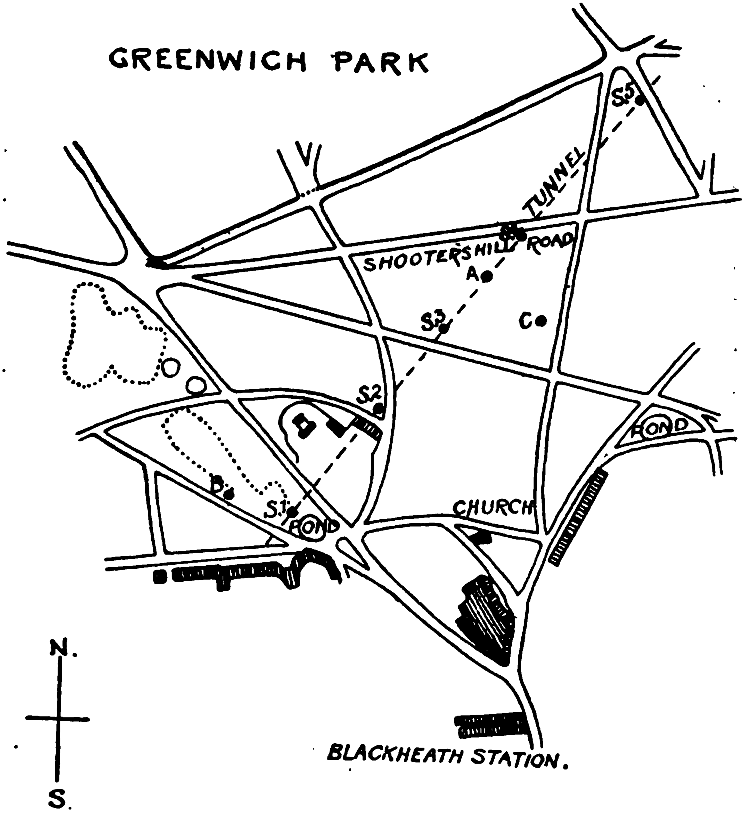
[1] The Lewisham and Blackheath Scientific Association (like so many local scientific societies) was short-lived, and came to an end in 1893. Hence it seems desirable to give a more detailed account of its work here than would otherwise be the case.



enlarged about that part at which water tended to enter, the material washed down, filling the chamber below and the lower part of the shaft. At last the cavity would become too large for stability, and the result would naturally be a subsidence at the surface taking the shape of that at pits A and C. Hypothetical sections illustrating these changes were added to my remarks appended to the report of the Exploration Committee.[1]

I now turn to events at Blackheath of a much more recent date. During the last year or two enclosures were made at intervals on Blackheath from a spot close to the "Hare and Billet" public-house, near Blackheath village, to the north-eastern corner of the heath close to the Charlton Road. They marked the positions of the shafts sunk along the course of the main drainage tunnel constructed in the Chalk beneath Blackheath. It soon became evident that the line taken by the tunnel, as indicated by the positions of two of these shafts, was such as to pass vertically beneath the site of the subsidence at A, which was, as already stated, precisely similar in size and shape to that at C, in which the Exploration Committee worked in 1881. Accordingly I wrote to Messrs. S. Pearson & Son, Ltd., the contractors, mentioning my interest in subterranean Blackheath, and expressing a desire for information as to their experience of it. My request was most kindly granted, and I am much indebted to a member of the firm, Mr. B. C. Cass, for the following additions to our knowledge of the geology of Blackheath.

Between a spot a few yards northward of the pond close to the "Hare and Billet" and another not far from the south-eastern corner of Greenwich Park there are five shafts along the line of the drainage tunnel. The shaft here called No. 1 is that near the "Hare and Billet"; No. 2 is close to but eastward of Talbot Place; No. 3 is close to but on the northern side of the road between the south-western corner of Greenwich Park and Morden College; No. 4 is near but south of the Shooters Hill Road; and No. 5 is about 70 yards southward of the south-eastern corner of Greenwich Park. The course of the tunnel is thus from south-west to north-east, and the portion of it which runs beneath the site of the subsidence at A is between shafts 3 and 4. As regards the depth at which water was met with during the sinking of these shafts, Mr. Cass gave me the following information:—

Shafts.	Depth at which water was found. ft. in.	Height of surface above ordnance datum. feet.
1	24 6	140
2	32 0	150
3	no water	150
4	32 0	146
5	32 0	147

He added that this water, which, percolating through the Blackheath Pebble Beds, is upheld by the more or less clayey beds of the Woolwich Series beneath, nowhere formed any serious obstacle to making the shafts. As regards shaft 3, in making which no water appeared, Mr. Cass stated that it was sunk some months later than Nos. 1 and 4, which were almost finished when No. 3 was begun. The details of the sections in shafts 2, 3, and 4 are here given:—

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[1] These sections, reproduced from the report, may be seen in the "Record of Excursions" of the Geologists' Association, pp. 5–8. They were introduced there to illustrate a very short report of an excursion to Charlton, Blackheath, and Lewisham conducted by Mr. J. Logan Lobley on April 30th, 1881, during which the subsidence at C was visited. The exploration was then in progress.

Shaft No. 2.

		Thickness.		Depth.	
		ft.	in.	ft.	in.
Blackheath Pebble Beds.	Soil	1	0	1	0
	Loamy gravel	24	0	25	0
	Yellow loamy sand	9	6	34	6
	White sand	4	6	39	0
Woolwich Beds.	Shell deposit	1	9	40	9
	Blue clay	3	9	44	6
	Pebbly sand	2	0	46	6
	Blue clay	0	6	47	0
	Loamy sand and pebbles	6	0	53	0
Thanet Sand.	White sand	48	6	101	6
	Black sand and flints	1	0	102	6
Chalk.	Bottom of shaft 123 ft. 3 in.				

Shaft No. 3.

		Thickness.		Depth.	
		ft.	in.	ft.	in.
Blackheath Pebble Beds.	Soil	1	0	1	0
	Loamy gravel	9	0	10	0
	White sand	23	0	33	0
	Loamy sand	5	0	38	0
Woolwich Beds.	Shell deposit	1	0	39	0
	Loamy sand	0	9	39	9
	Shell deposit	1	9	41	6
	Yellow clay	3	9	45	3
	Hard mixture of clay, sand, and pebbles	7	9	53	0
	Green sand	0	9	53	9
Thanet Sand.	White sand	48	9	102	6
	Black sand and flints	1	0	103	0
Chalk.	Bottom of shaft 123 ft. 3 in.				

Shaft No. 4.

		Thickness.		Depth.	
		ft.	in.	ft.	in.
Blackheath Pebble Beds.	Soil	0	6	0	6
	Dirty ballast	9	6	10	0
	Yellow clay	1	6	11	6
	Ballast	4	6	16	0
	Loamy sand	8	0	24	0
	White sand	1	3	25	3
	Loamy sand	5	8	30	11
	White sand	7	6	38	5
Woolwich Beds.	Red sand	2	3	40	8
	White sand	4	9	45	5
	Hard mixture of clay, sand, and pebbles	4	0	49	5
	Green sand	3	0	52	5
Thanet Sand.	White sand	48	1	100	6
	Black sand and flints	1	0	101	6
Chalk.	Bottom of shaft 119 ft. 9 in.				

If we compare the sections in these three shafts, we find that while the Thanet Sand is of the same thickness and character in each, and there is nothing peculiar in any of them as regards the Blackheath Beds, the Woolwich Beds are nearly alike in shafts 2 and 3 and differ noticeably from those of No. 4. On noting the absence of any "shell deposits" in the Woolwich Beds of No. 4, I wrote to Mr. Cass asking if they were non-existent in that shaft; for the word '*ballast*' being used for *gravel* in that section only, suggested a different reporter of the strata in that case. In reply Mr. Cass remarked:—"In No. 4 pit we did not come across any of the shell deposits as we did in Nos. 2 and 3. No. 4 was very free from shells, only very few being found in the sands." And as regards the spot between shafts 3 and 4 at which the tunnel passed beneath the hole formed by subsidence A on April 12th, 1878, Mr. Cass informed me that at a depth of about 120 feet the chalk there was found to be all broken up and mixed with material of various kinds which had fallen from above.

I have already alluded to the deep shaft ending in a chamber in the Chalk discovered at Eltham. Early in the year 1878 there was a leakage in the water-supply at Eltham Park, the seat of Mr. T. Jackson, about three miles from Blackheath. A disused brick drain, being opened up, was found to end at the top of a shaft 4 feet in diameter and 140 feet deep, at the base of which was a chamber in the Chalk, the extreme dimensions of which were 40 by 63 feet and the height 9½ feet. The lowest 22 feet of the shaft were cut through the Chalk, and it was lined throughout with courses of brick and chalk. Mr. Flinders Petrie read a paper describing it at a meeting of the Royal Archæological Institute on March 1st, 1878, from which these details are taken. At some period much later than that of its original construction, the chamber had been utilised as a cesspool, for a period, Mr. Flinders Petrie thinks, of "at least a century, perhaps two or three centuries." As to the objects of its makers, he finds no suggested explanation satisfactory. On that point I would only add that it seems evident that it must have been made for the sake of the chamber, and not for that of the material extracted therefrom, and consequently that it belongs to the denehole class.

The beds traversed by the shaft at this Eltham pit are the same as those at Blackheath. The Thanet Sand was 52 feet thick at Eltham, the Woolwich Beds 26 ft. 3 in., and the Blackheath Beds 37 ft. 9 in.; the top of the Chalk being 116 feet below the surface there, instead of 101 ft. 6 in. to 103 feet, as found near the sites of the Blackheath subsidences A and C. And while the nature of the beds composing Blackheath would be unusually easy to recognise in primitive times, as they are more or less visible close by, on the slopes of the Lower Tertiary escarpment, both northward and westward, there are no similar helps to observation at Eltham.

We have seen that the exploration of the subsidence at C, in 1881, showed that the strata vertically beneath were much shattered and mixed together, greasy clay being obtained at a depth of 84 ft. 6 in., where the Thanet Sand exists in undisturbed ground. And the course of the recent tunnel beneath the subsidence at A indicated that the Chalk there at a greater depth was broken up and mixed with other material from above. In addition we know that the appearances presented by both these subsidences at the surface were practically identical, their vertical sides suggesting shafts, while the expansion, beginning at a depth of about 18 feet from the surface, would be the natural result of the action of the water (met with at a depth of

32 feet in the recent shafts) on shafts disused and neglected for centuries. And of course this expansion, when it became too great for stability, would ultimately produce subsidences at the surface such as were once visible at A and C.

It may perhaps seem disappointing, at first, that something approximating to the discovery at Eltham in 1878 was not the result of the course taken by the recent tunnel beneath the site of the subsidence at A. But at Eltham the chamber in the Chalk was preserved because the shaft leading to it was preserved. It had escaped destruction through the exceptional circumstances that it had been utilized, in some way or other, centuries after the purposes of its originators had been forgotten. But in the case of the disused and neglected pits at Blackheath, the surface subsidences implied the simultaneous destruction of all that had up to that time remained of shaft and chamber below. The evidence afforded by the recent tunnel therefore confirms, as strongly as circumstances allow, the hypothesis that these Blackheath subsidences mark the sites where once existed shafts with chambers in the Chalk below, like the pit at Eltham.

Note.

This seems to be a good place for the introduction of the following brief acount of a Blackheath subsidence in the year 1798. It is from the *Gentleman's Magazine* for that year, p. 1078 :—

"Nov. 19. A singular accident happened last week at Blackheath. As a farmer and his son were conversing together in a field where a horse was feeding, on a sudden the animal sunk into the earth (hind feet first) to the depth of 15 feet, out of which he was dug, crushed to death. The cavity was only just sufficient to admit his body, the surrounding soil remaining firm."

This certainly suggests a subsidence resembling those at A and C. But its scene must have been a little east, or north-east, of the common now known as Blackheath.

VI.—PLANT REMAINS IN BASALT, MEXICO.

By Dr. M. M. SOLÓRZANO, of the Museo Michoacano, Morelia, Mexico, and BERNARD HOBSON, M.Sc., F.G.S., of the University of Manchester.

(PLATE XI.)

WHEN the members of the "Jorullo Excursion"[1] of the Tenth International Geological Congress were in the city of Morelia, in Mexico, they visited the College of St. Nicholas (founded in 1540), in the buildings of which is the Museo Michoacano. One of the most interesting objects in the Museum in question is a piece of basaltic lava containing remains of maize, which has been described by Dr. M. M. Solórzano, the Curator of the Museum, in an article entitled "Breve noticia acerca de algunos productos volcánicos de las immediaciones de esta ciudad" in the "Boletin de la Sociedad Michoacana de Geographia y Estadistica," Tomo ii, Núm. 8, Morelia, Julio 15 de 1906, pp. 59, 60.

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[1] See GEOL. MAG., 1907, p. 5.

The following is a translation of the last two paragraphs of the article: "To conclude these short notes, I will mention another volcanic product which, although it does not[1] occur in the environs of this city as do those previously described, is exceedingly interesting, since it proves not only the small conductivity of lavas in spite of their very high temperature, but also indicates, to a certain extent, the epoch in which volcanic phenomena were in full activity in the region where the rock I refer to was collected."

"This specimen, which is exhibited in the Museum before mentioned [Museo Michoacano], awakened the interest of that expert geologist and engineer, Mr. Ezequiel Ordóñez. It is a basaltic scoria which was collected [at the Hacienda de la Magdalena, distant only some 4½ leagues (11¾ English miles) from this city, and at a very short distance from the volcanic Pico de Quinceo],[2] and shows numerous and very distinct external impressions of female ears of maize and also entire grains and carbonized remains of the axis of the ear. (See Plate XI.) This seems to show that the inhabitants of the locality in question cultivated the plant just mentioned when a volcano [one of the extinct ones which exist between Quiroga and Patzcuaro][3] made the eruption which ejected the rock above described."

It is of interest to recall other occurrences of plant-remains in basalt. J. Macculloch[4] described and figured an erect coniferous tree in basalt at Gribon, Isle of Mull, which has subsequently been referred to by Mr. J. Starkie Gardner,[5] and illustrated from a photograph in Sir A. Geikie's "Scenery of Scotland" (3rd ed., 1901, p. 142).

Mr. H. M. Cadell[6] has described the remains (12 inches long) of a Lycopod stem in basalt at Cowdenhill, Grangepans.

Mr. J. D. Dana, describing the Kilauea (Sandwich Islands) lava of the 1840 eruption, says:[7] "The rapidity with which lava cools is still more remarkably shown in the fact that it was found sometimes hanging in stalactites from the branches of trees; and although so fluid when thrown off from the stream as to clasp the branch, the heat had barely scorched the bark." Describing the Kilauea eruption of 1868, he remarks:[8] "As has happened in most Hawaiian eruptions, trees were enveloped by the lava-flood. Half-charred trunks were standing in 1887 with a rough cylindrical encasement of lava about the stumps."

Mr. J. S. Diller[9] has described a tree pushed over by the advancing lava stream of the Cinder Cone, 10 miles north-east of Lassen Peak, and gives a plate (No. xiv) showing the tree in the lava.

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[1] In view of the correction mentioned below the "not" should be omitted.

[2] This is the correct locality according to a letter of November 3rd, 1906, from Dr. Solórzano to me. The printed account states "in the vicinity of Quiroga, District of Morelia."

[3] This is incorrect owing to the true locality being different.

[4] "A Description of the Western Islands of Scotland," etc.: vol. i (1819), p. 568.

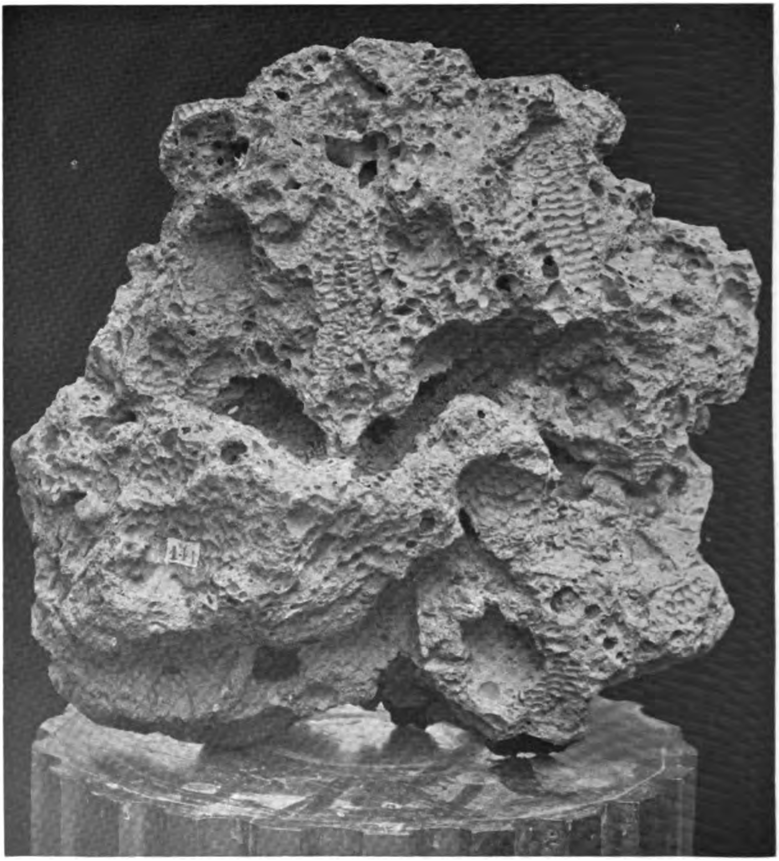
[5] Quart. Journ. Geol. Soc., 1887, p. 283.

[6] "The Occurrence of Plant Remains in Olivine Basalt in the Bo'ness Coalfield": Trans. Geol. Soc. Edin., vol. vi (1892), pp. 191–193, pl. vi. (See *infra*, p. 219.)

[7] "Characteristics of Volcanoes," etc.: 1890, p. 64.

[8] Loc. cit., p. 91.

[9] "A Late Volcanic Eruption in Northern California and its peculiar Lava": Bulletin No. 79, U.S. Geol. Survey, 1891, p. 20.



Remains and Impressions of Ears of Maize in Basalt, Morelia, Mexico.

Slightly less than one-third linear of the size of the original specimen.

The late Mr. F. A. Fouqué, describing some phenomena observed on Etna, says[1] (trans.): "The lava of the 1865 eruption flowed through the midst of a wood of lofty trees. . . . Many trees had been torn up or burnt. Nevertheless, a great number of them remained standing on each side of the fissure, in spite of the movements of the ground and in spite of the incandescent current which had for a moment surrounded them. The trees thus preserved were all, without exception, surrounded by a stony sheath formed of solidified lava. The interior surface of this sheath had moulded itself on the surface of the tree, of the bark of which it sometimes reproduced all the details with surprising fidelity."

Mr. R. H. Walcott[2] has described a pseudomorphous replacement by solid basalt of a tree 10 feet high with a branch and roots. The stem has an average circumference of 31 inches: "The surface bears a number of corrugations and has the identical appearance of bark." "The surrounding basalt comprising the mould in which the tree was formed, judging from the two available pieces, is to all appearances of the same nature as the cast." The cast was found in a quarry at Footscray (which appears to be close to Melbourne).

DESCRIPTION OF PLATE XI.

The photograph shows the piece of scoriaceous basalt preserved in the Michoacan Museum, Morelia, Mexico. The specimen measures 12·09 inches in height, 13·26 in width, and 7·60 in thickness (front to back). Impressions of ears of maize are shown on the right (*a*) just below the right upper corner, (*b*) towards centre of margin overhanging a cavity, (*c*) at the two right bottom corners; but the most striking example is just above the two converging central cavities, where an ear in a vertical position shows not only impressions but actual grains of maize. Several other impressions occur, but are indistinct in the plate. The figure is slightly less than ½ linear of the size of the original specimen.

[In connection with the foregoing note on Plant-remains in Basalt from Mexico, the subjoined observation by Mr. H. M. Cadell, B.Sc., F.R.S.E., reprinted from the Trans. Geol. Soc. Edinb., vol. vi (1892), pl. vi, pp. 191–193, deserves to be recorded here.—EDIT. GEOL. MAG.]

VII.—THE OCCURRENCE OF PLANT REMAINS IN OLIVINE BASALT IN THE BO'NESS COALFIELD.

By HENRY M. CADELL, B.Sc., F.R.S.E.

(PLATE XIV.[3])

IN a paper which I read before the Edinburgh Geological Society on 26th January, 1880, and which appears in the Transactions, vol. iii, pp. 304–325, a general stratigraphical account is given of the extensive series of interbedded volcanic rocks of the Bo'ness Coalfield in Linlithgowshire.

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[1] "Sur la non-altération des couches de houille en contact avec des roches éruptives": Bull. Soc. géol. France, ser. II, vol. xxiii (1866), pp. 190–193.

[2] "Note on a Basalt Tree Cast": Proc. Roy. Soc. Victoria (Australia), new series, vol. xii, pt. 2 (1900), pp. 139–144, pl. xiii.

[3] The block for Plate XIV has been obligingly lent by the author, Mr. H. M. Cadell, F.R.S.E.

Some new facts of considerable geological interest have since been elicited in the course of mining and quarrying operations in the district. Among these the most remarkable is perhaps the discovery of undoubted fragments of plants in some of the sheets of basalt interstratified with the Carboniferous beds. In my former paper I referred to the occurrence of coniferous wood in some of the ash beds and neck tuffs that belong to the old volcanoes of the Carboniferous Limestone Series of Linlithgowshire, but such plant-remains, although interesting, are not particularly remarkable or surprising in their mode of occurrence, as similar remains have been found elsewhere, and their origin is not at all difficult of explanation.

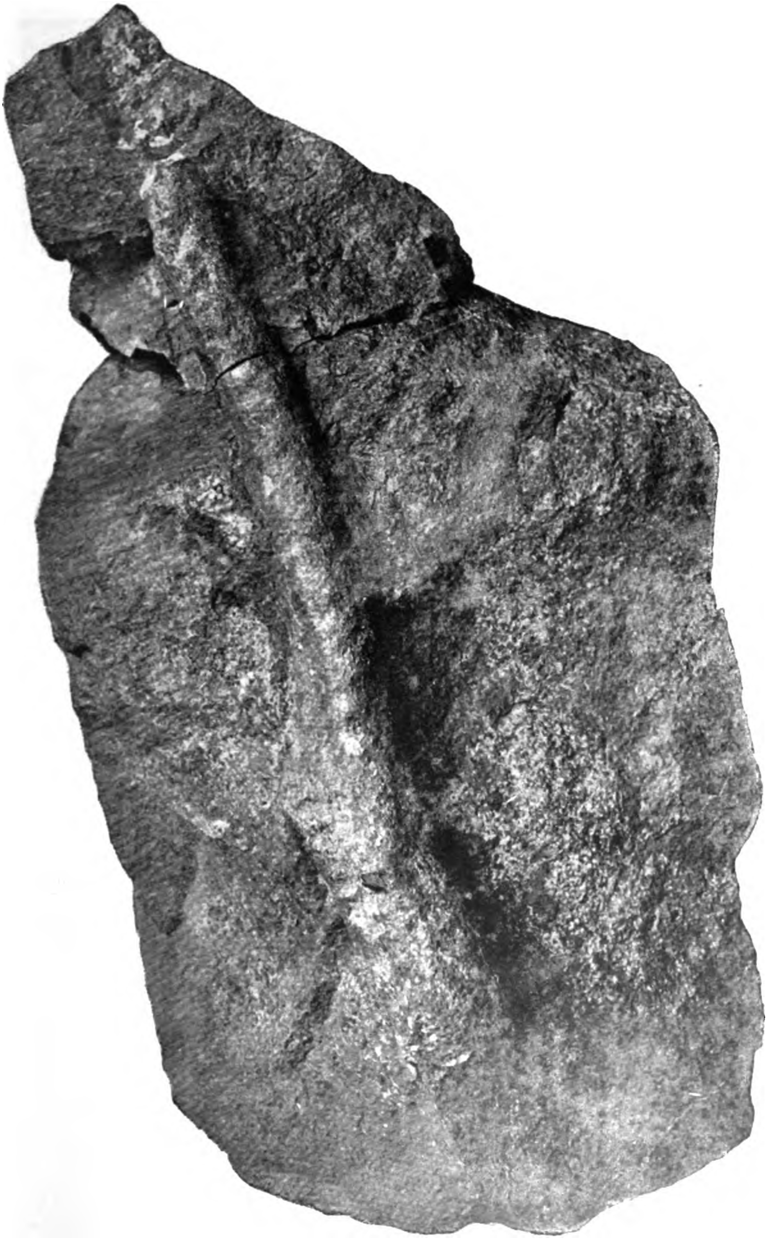
The plant-remains I shall now briefly describe were found under much more unusual circumstances, and I may safely say that very few, if any, similar cases have been discovered in this country at least, in which the matrix surrounding the fossil consists of a crystalline massive volcanic rock.

During the Summer of 1890 I had occasion, while carrying out some improvements at Cowdenhill, in the village of Grangepans, to remove part of a knoll of trap that forms a low cliff on the south side of the public road. The trap in question is the bed that lies in this part of the Bo'ness coalfield, about 30 feet above the seam known as the Red Coal. It dips westward from its outcrop at Cowdenhill, and has been pierced in No. 3 Pit of Grange Colliery about 80 yards further west, where it has a thickness of about 27 feet. That the rock is contemporaneous and not intrusive is clearly proved from the fact that (1) it has never been found to cut across the strata in the many sections where it has been laid bare; (2) the beds below are slightly indurated at places, while those above are unaltered; (3) the upper surface is highly amygdaloidal and usually somewhat decomposed.,

Where the excavation was made there is no means of ascertaining the distance from the top or bottom of the trap, but the rock is here quite solid and free from amygdules, and less decomposed than it usually is near the edges, so that the specimen to which I shall now refer was probably taken from near the centre of the old lava bed.

When first it was brought to light I took it for some species of mineral concretion, but a little examination soon proved that this could not be the case, as it not only looked remarkably like a lycopod stem, but was surrounded by a thin film of what appeared to be black carbonaceous matter. My friend Mr. R. Kidston, F.R.S.E., F.G.S., who kindly examined it and took the photograph which is reproduced in the accompanying plate (Pl. XIV), reports as follows:—

"The specimen, which is preserved in greenstone (basalt), is 12 inches long. The upper extremity is about 1$\frac{1}{10}$ inch in diameter, and owing to a fracture in the stone which contains the fossil the upper 3 inches are broken off and lift out of the matrix. In section the stem at this part is slightly compressed on one side. The lower extremity measures 2 inches in its greatest diameter, but it is also slightly compressed. About 4 inches from the base a branch has been given off on the left side of about equal size to the stem preserved, but only its truncated base is left to indicate its position.



Plant-remains in Basalt, from the Bo'ness Coalfield, Linlithgowshire.

The fossil lies on the angle ridge of a rudely four-sided block, whose shape is determined by the natural jointing of the basalt, and, like the exposed surfaces of the stone, is stained an ochreous brown colour. With the exception of this very thin coating of iron oxide, and perhaps a little carbonaceous matter mixed with it, the original plant in its upper part is entirely replaced by crystalline calcite, as shown at the fracture in the specimen to which reference has already been made.

"The broken base (which only in part shows a fresh surface) appears to consist of lime and matrix intermingled, but this may not be more than a coating at the broken end.

"There cannot remain the slightest doubt that the fossil is part of a *Lycopod* stem. Its outer surface might be described as an imperfectly preserved specimen of *Knorria*, which, however, may have originated from a *Lepidodendron* or a *Lepidophloios*.

"The great interest of the specimen centres in the matrix in which it is preserved. The occurrence of a plant preserved in basalt is perhaps unique. The fossil was probably first reduced to a condition of 'charcoal' by the heat of the lava—a condition in which specimens are frequently found in volcanic ash—and subsequently the carbon has been removed and the cavity filled up by infiltrated lime."

I had some of the most carbonaceous-looking parts sliced for the microscope, but a close examination failed to show any traces of vegetable structure.

A microscopic examination of the rock, which Mr. J. G. Goodchild, F.G.S., has been kind enough to make, shows it to present the character of a medium-grained, hemicrystalline aggregation of (1) lath-shaped crystals of plagioclase, apparently labradorite, forming quite three-fifths of the mass; (2) a small quantity of a mineral too much decomposed to be recognizable, but which may have been one of the pyroxenes; (3) large grains of serpentinised olivine of characteristic form and optical properties; (4) magnetite in small grains and crystals, evidently representing the oldest crystallization; (5) more or less interstitial matter, which remains dark through a complete rotation under crossed nicols, and which must, therefore, represent undifferentiated matter that originally existed as glass. The presence of olivine, which is even more abundant than that in the olivine basalt of the Lion's Haunch (Arthur's Seat), along with abundant plagioclase felspar and a ground-mass, shows the rock to be an olivine basalt.

In conclusion, it is interesting to reflect that had such a discovery been made three-quarters of a century ago, when the Huttonian and Wernerian controversy was at its height, it would doubtless have been triumphantly adduced as a proof of the correctness of the Neptunists' view that greenstone and trap are rocks of aqueous sedimentary origin, in which organic remains might reasonably be expected to occur.

VIII.—THE FAUNA OF THE BOKKEVELD BEDS.

By F. R. COWPER REED, M.A., F.G.S.

(*Concluded from the April Number*, p. 171.)

THE conspicuous relations of the brachiopod fauna of these beds to that of the Lower Devonian in South America have frequently been pointed out, and may be summarised as follows:—

(1) In the Falkland Islands the following South African species are found (12):—

Chonetes falklandicus.
Orthothetes Sulivani.
Stropheodonta concinna.
Leptocœlia flabellites.
Spirifer antarcticus.
Cryptonella Baini.
Orbiculoidea Baini.

(2) On the South American continent the following identical or allied species occur:—

SOUTH AFRICA.	SOUTH AMERICA.
Lingula aff. *densa*	*Lingula Coheni*, Ulr. B.
Orbiculoidea Baini	*Orb. Baini.* Br. *Discina* sp. *α*, Ulr. B. *Orb.* cf. *humilis*, Hall. A., Br.
Strophonella sp.	*Strophomena* sp. *β*, Ulr. B.
Orthothetes Sulivani	*Orth. Agassizi*, Hartt. Br. *Orth.* sp. *α*, Ulr. B.
Chonetes falklandicus	*Ch. Comstocki*, Hartt. Br. *Ch. Rucki*, Ulr. B. *Ch. falklandicus.* A., Br.
Ch. cf. *Arcei*	*Ch. Arcei*, Ulr. A., B.
Ch. cf. *coronatus*	*Ch. coronatus*, Conr. A.
Orthis sp. ?	*Orthis* sp. *β*, Ulr. B.
Leptocœlia flabellites	*Lepto. flabellites*, Conr. A., B., Br.
Vitulina pustulosa	*Vit. pustulosa*, Hall. A., B., Br.
? *Tropidoleptus carinatus*	*Trop. carinatus*, Conr. B., Br.
Retzia cf. *Adrieni*	*Retzia ? wardiana*, Hartt & Rath. Br.
Trigeria ? simplex	*Rhynchospira ? jamesiana* (Hartt). Br.
Rhynchospira ? Silveti	*Rh. ? Silveti*, Ulr. B.
Scaphiocœlia africana	*Scaph. boliviensis*, Whitf. B.
Cryptonella Baini	*Crypt. Riskowski*, Ulr. B.
Cryptonella ? sp.	*Oriskania navicella*, Hall & Clarke. Br.
Spirifer antarcticus + *Orbignyi*	*Sp. antarcticus*, M. & S. A. *Sp. Chuquisaca*, Ulr. B., Br. *Sp. buarquianus*, Rath. Br.
Sp. Ceres	*Sp. lauro-sodreanus*, Katz. Br.
Sp. cf. *pedroanus*	*Sp. pedroanus*, Hartt & R. Br.

B. = Bolivia; Br. = Brazil; A. = Argentina.

It is noteworthy that no members of the genera *Rensselæria* or *Ptychospira* have so far been recorded from South America.

Ulrich (16) was the first to remark upon the affinities of the South African brachiopods of the Bokkeveld Beds to those of the Hamilton Group in North America, and especially referred to *Leptocœlia flabellites* and *Vitulina pustulosa*. The following allied or identical species have so far been noticed as occurring in the North American Devonian:—

SOUTH AFRICA.	NORTH AMERICA.
Lingula aff. *densa*	*Lingula densa*, Hall.—Hamilton.
Orbiculoidea Baini	*Orb. humilis*, Hall. Marc. and Ham.
Strophonella cf. *concinna*	*Stroph. perplana*, Conr. Up. Held.-Chemung.

Strophonella sp.	*Stroph. ampla*, Hall. Up. Held.
Orthothetes Sulivani	*Orth. chemungensis*, Conr. Chemung.
Chonetes cf. *coronatus*	*Ch. coronatus*, Hall. Ham.
Ch. aff. *setiger*	*Ch. setiger*, Hall. Marc.-Waverly.
Orthis sp. ?	*Orthis lepidus*, Hall. Ham.
Rhynchonella sp. ?	*Rh. Horsfordi*, Hall. Marc. and Ham.
Rensselæria sp. *a*, Reed (? = *R. relicta*, Schwarz)	*R. ovoides*, Eaton. Oriskany.
R. sp. *β*, Reed	*R. Cumberlandiæ*, Hall. Oriskany.
Trigeria aff. *Gaudryi*	*Trigeria Gaudryi*, Oehl. Oriskany.
Leptocœlia flabellites	*Lepto. flabellites*, Conr. Orisk. and Cornif.
Vitulina pustulosa	*Vit. pustulosa*, Hall. Ham.
Ambocœlia umbonata	*Amb. umbonata*, Conr. Marc.-Chemung.
? *Tropidoleptus carinatus*	*Trop. carinatus*, Conr. Marc. and Ham.
Cryptonella Baini	*Crypt. planirostra*, Hall. Marc. and Ham.
Cryptonella ? sp.	*Oriskania navicella*, Hall & Clarke. Oriskany.
Spirifer antarcticus + *Orbignyi*	*Sp. arrectus*, Hall. Oriskany.
Sp. cf. *pedroanus*	*Sp. mucronatus*, Conr. Marc., Ham., and Chem.
Spirifer Ceres	*Sp. raricosta*, Conr. Up. Held. *Sp. duodenarius*, Hall. Up. Held.
Sp. sp. *a*, Reed	*Sp. medialis*, Hall. Marc. and Ham. *Sp. mucronatus*, Conr. Marc., Ham., and Chem.

The ranges of the American forms are taken from Schuchert's list (18).

The foregoing list shows the strong and close affinities of the Bokkeveld brachiopods to those of the Devonian of North America, and it is remarkable that, according to Katzer (17, p. 199), in the case of the Brazilian members of the same group from the Maecuru Sandstone, there is a mixture of upper Lower Devonian and Middle Devonian forms, the Lower Devonian predominating; but in South Africa the facies is more that of the Middle.

Haug (11) has recorded several brachiopods from the Devonian beds of Tassili in the Sahara which suggest the presence of the Bokkeveld fauna, or at any rate of elements of it. The occurrence of *Spirifer* cf. *Rousseaui* has been mentioned above. The form called by Haug *Stropheodonta oriskania*, Clarke, and compared with Sharpe's *Chonetes*? sp. (14, p. 209, pl. xvi, fig. 14) from South Africa appears to me to resemble more closely my *Stroph.* cf. *concinna* (Morr. & Sh.). The specimen figured as *Chonetes* sp. by Haug may be compared with my *Ch.* aff. *setiger*. The important species *Leptocœlia flabellites* is definitely identified by Haug from Tassili. Schwarz (2) doubts the accuracy of Haug's determinations, but apparently has only the figures by which to judge.

(*c*) *Mollusca.*

The list of Mollusca (22) (2) (23) from the Bokkeveld Beds is as follows:—

Orthoceras gamkaensis, Reed.
O. bokkeveldensis, Reed.
O. rex, Schwarz.
Pleurotomaria aff. *Kayseri*, Ulr.
Bellerophon quadrilobatus, Salter.
B. (*Bucaniella*) aff. *trilobatus*, Sow.
B. (*Bucaniella*) cf. *Reissi*, Clarke.
B. cf. *morganianus*, Hartt & Rath.
B. (*Plectonotus*) aff. *Salteri*, Clarke.
Loxonema sp.
Holopea Baini, Sharpe.
Diaphorostoma ? sp.
Tentaculites crotalinus, Sharpe.
T. Baini, Reed.
Hyolithes subæqualis (Salter).
Conularia africana, Sharpe.
C. quichua, Stein. Död.
C. cf. *undulata*, Conr.
C. cf. *acuta*, Roem.
Nuculites abbreviatus (Sharpe).
N. africanus (Salter).
N. Branneri, Clarke.

Nuculites capensis, Reed.
N. colonicus, Reed.
N. lunulata, Schwarz.
N. martialis, Reed.
N. ? *ovatus* (Sharpe).
N. cf. *Smithi*, Clarke.
Palæoneilo antiqua (Sharpe).
P. ? *arcuata*, Schwarz.
P. Boyeri, Schwarz.
P. rudis (Sharpe).
P. subantiqua, Reed.
P. aff. *constricta* (Conr.).
P. cf. *fecunda*, Hall.
P. sp. ind., Reed.
Nuculana (= *Leda*) *inornata* (Sharpe).
Buchiola subpalmata, Reed.
B. sp. ind., Reed.
Cardiomorpha campestris, Reed.
Præcardium ? sp., Reed.
? *Cypricardella Pohli*, Clarke.
Anodontopsis ? *rudis* (Sharpe).
Orthonota aff. *undulata* (Conr.).
Grammysia corrugata (Sharpe).
Gr. sp.
Sanguinolites niger, Reed.
S. ? *acer*, Reed.
Glossites aff. *depressus*, Hall.
Nyassa arguta, Hall.
Modiomorpha Baini (Sharpe).
M. cf. *pimentana*, Hartt & Rath.
M. aff. *Sellowi*, Clarke.
Byssopteria ? sp.
Actinopteria aff. *Boydi*, Conr.
Act. sp. ind., Reed.

The relations of these species to those from the Devonian of South America are shown below :—

South Africa.	South America.
Orthoceras gamkaensis	*Orthoceras* sp. *a*, Ulr. B.
Pleurotomaria aff. *Kayseri*	*Pl. Kayseri*, Ulr. B.
Bellerophon cf. *morganianus*	*B. morganianus*, Clarke. Br.
B. quadrilobatus	*B. Derbyi*, Cl. Br. *B.* sp. *a*, Ulr. B.
B. cf. *Reissi*	*B. Reissi*, Cl. Br. *B. coutinhoana*, Cl. Br.
B. aff. *Salteri*	*B. Salteri*, Cl. Br.
Tentaculites crotalinus	*T. crotalinus*, Salt. A. *T.* sp. A. *T. bellulus*, Hall. B., Br.
T. Baini	*T. eldredgianus*, Hartt & Rath. Br.
Hyolithes subæqualis	*H. Schencki*, Ulr. B.
Conularia africana	*C. africana*, Sh. B.
C. quichua	*C. quichua*, Stein. Död. B., A.
C. cf. *undulata*	*C. undulata*, Conr. B.
C. cf. *acuta*	*C.* cf. *acuta*, Roem. B.
Nuculites africanus	*N. Beneckei*, Ulr. B.
N. cf. *Smithi*	*N. Smithi*, Cl. Br.
N. Branneri	*N. Branneri*, Cl. Br.
Palæoneilo rudis	*P. Orbignyi*, Cl. Br.
P. antiqua	*P. Forbesi*. B.
Nuculana (= *Leda*) *inornata*	*L. diversa*, Hall. Br. *L.* sp. *a*, Ulr. B.
? *Cypricardella Pohli*	*C. Pohli*, Cl. Br.
Modiomorpha cf. *pimentana*	*M. pimentana*, Hartt & Rath. Br.
M. aff. *Sellowi*	*M. Sellowi*, Cl. Br.
Grammysia corrugata	*G. Ulrichi*, Cl. Br.
G. sp.	*G. Gardneri*, Cl. Br.
Actinopteria aff. *Boydi*	*A.* cf. *Boydi*, Conr. B. *A. Eschwegei*, Cl. Br.

It is obvious from the above list that there is an unusually large number of closely allied or representative species amongst the mollusca. But we may note the absence from South Africa (so far as our present knowledge extends) of the genus *Platyceras*, which is represented in South America by ten or more species, and is very common in the Devonian of the Amazon. There are likewise some lamellibranch genera present (*Buchiola*, *Glossites*, *Cardiomorpha*, etc.) which appear not to be present in South America, while the latter region possesses others (*Tæchomya*, *Sphenotus*, *Cimitaria*, etc.) which have not so far been definitely recognised in South Africa. But negative evidence of this kind under the circumstances is of little import.

Of Bokkeveld species of mollusca allied to or identical with North American Devonian forms, the following list may be given:—

SOUTH AFRICA.	NORTH AMERICA.
Orthoceras bokkeveldensis	*O. typum*, Roem.
Pleurotomaria aff. *Kayseri*	*Pl. lucina*, Hall. Up. Held. and Ham. *Pl. Hebe*, Hall. Up. Held.
Loxonema sp.	*L. delphicola*, Hall. Ham.
Tentaculites crotalinus	*T. bellulus*, Hall. Ham.
Hyolithes subæqualis	*H. ligea*, Hall. Schoharie.
Conularia africana	*C. elegantula*, Meek. Up. Held.
C. cf. *undulata*	*C. undulata*, Hall. Ham.
Nuculites capensis	*N. oblongatus*, Conr. Ham.
N. martialis	*N. triqueter*, Hall. Ham.
N. cf. *Smithi*	*N. elongatus*, Conr. Ham.
Palæoneilo Boyeri *P.* cf. *fecunda*	*P. fecunda*, Hall. Ham.
P. aff. *constricta*	*P. constricta*, Conr. Ham.
Nuculana (*Leda*) *inornata*	*L. diversa*, Hall. Ham.
Buchiola subpalmata	*B. speciosa*, Hall. Genn.
Orthonota aff. *undulata*	*O. undulata*, Conr. Ham.
Grammysia sp.	*G. alveata*, Conr. Ham. *G. lirata*, Hall. Up. Held. and Ham.
Nyassa arguta	*N. arguta*, Hall. Ham.
Glossites aff. *depressus*	*G. depressus*, Hall. Chem. *G. lingualis*, Hall. Chem.
Modiomorpha Baini	*M. alta*, Conr. Ham.
Actinopteria aff. *Boydi*	*A. Boydi*, Conr. Ham.

There is a plain Hamiltonian (Middle Devonian) facies in the mollusca of the Bokkeveld Beds which is brought out by the above list. The same feature is noticeable to a certain extent in the Devonian of South America, especially in Brazil, according to Katzer (17, p. 199).

Haug (19) has recently recorded *Conularia africana* and *Actinopteria* aff. *Boydi* from the Devonian of the Central Sahara in addition to the brachiopods and trilobites above mentioned, and the evidence for the occurrence of the Bokkeveld fauna in Northern Africa is thus gaining strength.

(*d*) *Miscellaneous.*

The remaining few fossils from the Bokkeveld Beds belong to various groups, and comprise the following:—

Serpulites rica, Salter.
Ophiocrinus Stangeri, Salter.
Ophiuroids (undescribed).
Zaphrentis zebra, Schwarz.

GENERAL CHARACTERS OF THE FAUNA.

Reviewing the fauna as a whole, we note the abundance of species of brachiopods, lamellibranchs, and trilobites, and this abundance is also expressed in individuals. These groups compose the bulk of the whole fauna. Cephalopods are very rare, and corals are practically absent. Certain genera predominate in the three main groups:

amongst the trilobites *Homalonotus* and two special subgenera of *Phacops*; amongst the brachiopods *Spirifer*, and members of the genera variously termed *Rhynchospira*, *Retzia*, *Rensselæria*, and *Trigeria*, while *Lepto. flabellites* is the most abundant form of all. *Chonetes* is also represented by several distinct species, and is not an uncommon form. The most prominent Mollusca are *Bellerophon* (*Bucaniella*), *Conularia*, *Palæoneilo*, and *Nuculites*, the two latter containing at least 16 species. All other groups are very poorly represented.

Further research may somewhat alter the proportions of the various groups and reveal new species and genera, but is scarcely likely to lead to a complete re-casting of our conclusions.

RELATIONS TO DEVONIAN FAUNAS OF OTHER REGIONS.

(*a*) *South America.*

The close relations of the Bokkeveld fauna to that of the Devonian beds of South America have been brought out in comparing the trilobites, brachiopods, and mollusca separately, and they have been remarked by all workers on the fossils. Katzer (15, p. 28) has especially compared the Amazonian fauna with it, and concludes that they are of the same age. The intimate nature of the relations between the several Devonian faunas of South America itself has been emphasised by the same author as well as by Clarke (8*a*, pp. 80–90) and Thomas (10).

(*b*) *North America.*

The same authors lay stress on the resemblance of these various Devonian faunas of South America to that of the Hamilton Beds of North America. Kayser (20, p. 317) had previously insisted on this point, and we have seen the strength of the same resemblance in the case of the South African fauna. Moreover, the same peculiar admixture of Lower Devonian forms with those of Middle Devonian age is likewise noticeable in South Africa, but the latter predominate and give the principal features to the fauna of the Bokkeveld Beds.

In South Africa there are species allied to or identical with those of the Upper Helderberg Group (including the Oriskany Sandstone), of the Hamilton Group, and of the Chemung Group; and Katzer (15, pp. 20–22) has recognised the same in the Amazonian faunas. The conclusion to which Thomas (10) is led with regard to the age of all the South American Devonian beds is that it is close upon the borders of the Lower and Middle Devonian. But Katzer is of the opinion that the Devonian fauna of the Amazon, and especially the Maecurú fauna, is more closely connected with the Middle than with the Lower Devonian of North America; and it is to this conclusion I am brought by the foregoing study of the affinities of the Bokkeveld fauna. The evidence of each zoological group, so far as it is known, points in this direction, and I believe it is largely the lithological resemblance of the beds to the well-known Spirifer Sandstone of the Rhenish Lower Devonian which at first inclines one to put the South African beds on the lower stratigraphical horizon. But to this feature reference is again made below.

(*c*) *Europe.*

If we compare the fauna of the Bokkeveld Beds with that of Southern and Western Europe, as Katzer (15, pp. 36–40) has done for the South American Devonian, we may together with him first notice that it is on the banks of the Bosphorus (24) that we seem to get a peculiar resemblance, as the Lower (?) Devonian fossils described by De Verneuil (24) show. In connection with the Bolivian fauna Ulrich (9) has similarly drawn attention to this fact, and points to the presence of ribbed Centronellids, of members of the group *Bellerophon trilobatus*, of two species of *Homalonotus* allied to *H. acanthurus*, of a *Cryphæus* recalling *C. paitúna*, and of *Tropidoleptus carinatus* (usually described in Europe as *Strophomena laticosta*, D'Orb.). Clarke has referred to this resemblance in the case of the trilobites of the Maecurú (8, pp. 43, 46). Further investigation of these Bosphorus Beds might yield interesting and important results in this connection. But at present the evidence is scanty and insufficient.

In Western Europe it is in the fauna of the Coblenz Beds (upper Lower Devonian) that one finds the strongest and most numerous points of resemblance. As above mentioned, the similarity in the lithological characters of the rock and mode of preservation of the fossils are additionally suggestive and lend a certain assistance in any comparison. But when we come to compare the species separately and minutely we do not find such a close agreement or so much affinity as might be expected. Amongst the trilobites it is chiefly in the species of *Homalonotus* that we find degrees of relationship, and these may not be so close as has been urged (2). According to Lake *H. Herscheli* has its nearest ally in *H. armatus*, Burm, from the Lower Coblenz Beds; and *H. quernus* in *H. subarmatus*, Koch, from the Upper Coblenz Beds. The Phacopidæ belong to quite distinct types, though the Bokkeveld *Dalmanites* may belong (like *D. maecurua*, Clarke, from the Amazon) to the widespread *Hausmanni* group. Amongst the brachiopods we have the group of *Sp. antarcticus* closely related to *Sp. primævus* and its allies; *Ch. falklandicus* is allied to *Ch. sarcinulata*; *Retzia Adrieni*, De Vern., occurs typically in the Lower Devonian of Europe, and so does *Trigeria Gaudryi*; and *Ambocœlia umbonata* has been recorded from Western France; *Orthothetes Sulivani* has certain affinities with the well-known *O. umbraculum* from the Middle Devonian of Europe. *Rhynchospira* (?) *Silveti* is probably allied to *Centronella Bergeroni*, Oehl., and perhaps to *C. Guerangeri* (De Vern.), both of the Lower Devonian, and *Ptychospira variegata* finds its nearest ally in the Middle Devonian form *Pt. ferita*, Von Buch, and the genus is not known from South America. *Rensselæria confluentina* is a Rhenish Lower Devonian species. If *Tropidoleptus carinatus* occurs in the Bokkeveld Beds it is represented in Europe by the identical *Strophomena laticosta*.

The Mollusca which show affinities to European forms are the following:—

Bellerophon aff. *trilobatus* ...	*B. trilobatus*, var. *tumidus*, Sandberger. Lr. Dev.
Conularia cf. *acuta*	*C. subparallela*, Sandb. Lr. Dev. *C. acuta*, Roem. Lr. Dev.
Grammysia sp.	*G. ovata*, Sandb. Lr. Dev.

Nuculites Branneri *N. colonicus*	*Cucullella elliptica*, Maur. Lr. Dev.
N. capensis	*N. solenoides* (Goldf.). Lr. Dev.
Buchiola subpalmata	*B. palmata* (Goldf.). Mid. Dev.
Sanguinolites niger	*S. Marsi*, Oehl. Lr. Dev.
Actinopteria aff. *Boydi*	*Act. Trigeri*, Oehl. Lr. Dev.

We have therefore to acknowledge a certain degree of affinity to the fauna of the Coblenzian Beds, but it is of much less strength than that shown to the North American beds.

The problem, however, now confronts us of the alliance of the Bokkeveld fauna being closer with the *Middle* Devonian of North America than with the Lower, while in Europe it is with the undoubted *Lower* Devonian fauna that we find most points of resemblance. The same difficulty has to be faced with regard to the South American fauna, and Katzer (15) inclines to the explanation that the European Lower Devonian forms migrated to America, appearing and living on later there so as to form an element in the Middle Devonian of that area. Probably the physical conditions which they found, especially in South America, and we may add South Africa, were conducive to their persistence, as these resembled the Coblenzian of Western Europe. By this attitude Katzer is in favour of the non-contemporaneous appearance of the same or closely allied forms in Europe and America; and he suggests that the whole movement and dispersion of the faunas was connected with that widespread transgression of the Middle Devonian seas of which fresh evidence is constantly being found (25). It was, however, the typical West European Middle Devonian fauna which spread over the widest area, but its extension is found to the east of its well-known habitat in Western Europe, and not to the south or west. It has been discovered throughout Central Asia northwards to Shantung and southwards to Burma, and as far as Australia, a growing admixture of American forms being generally noticeable as we proceed eastwards. The characteristic calcareous development of this type is in marked contrast to the arenaceous or argillaceous nature of the South African and South American beds, and the physical conditions must naturally have largely influenced the composition of the faunas.

The whole question of the migration of faunas, particularly in connection with the Devonian beds of North America, has been recently discussed in much detail by H. S. Williams (31), and he has shown by a wide collection of facts and statistics that there was frequent lateral shifting, emigration, recurrence, and overlapping of faunas living in the same general marine province, with occasional invasions of strange faunas from neighbouring or distant areas. Migrations have been usually attended by modifications of some of the species, or of their proportionate abundance; other forms which were unable to shift or adapt themselves to new conditions with sufficient rapidity become extinct, while others are stimulated to mutation (in De Vries' sense) and new types are produced. An incorporation of elements previously existing in the invaded area may also be occasionally noticed. In this way the survival of an older fauna in its integrity, or at any rate of a considerable remnant, may take place owing to lateral shifting, and the lifetime (biochron) of any fauna does not necessarily, or even generally, coincide with the limits of the formation in which it is typically developed, nor does faunal equivalency necessarily imply contemporaneity of formation.

If we look upon the Bokkeveld fauna in this light we may regard the European Coblenzian elements as the late survivals of a migratory movement from the north, while the general facies is that of the American Middle Devonian modified by and incorporated with the special fauna of the Southern Ocean and with the local types of the South African region of the period.

DISTRIBUTION.

In the construction of Katzer's sketch-map (15, pp. 40–50) showing the general distribution of sea and land at the beginning of Middle Devonian times the distinctive characters of the faunas and of the rocks in which they occur have been utilised, and with the exception of Haug's important discoveries in the Sahara there has been no new evidence to disturb the general outlines there shown for the southern hemisphere. In the case of the northern hemisphere Schuchert's (27) work on the North American Devonian palæogeography and Lebedew's (28) researches on the distribution of Devonian corals in Asiatic Russia and Europe may necessitate some modifications into which one need not here enter. In his map Katzer shows a great continental mass of land which he terms the 'Atlantic-Ethiopian continent,' extending all over the North and Central Atlantic, covering a great part of North America and the whole of Africa, except the northern portion and the Cape. A great 'Southern Ocean' washes the southern shores of this continent, and on its eastern side this ocean is connected with the main European marine areas by an 'Indian Connecting Sea,' or rather broad straits, reaching up from the present Indian Ocean across Arabia and Asia Minor, and thus linking up the Bosphorus fauna with that of the Cape. On the west side of the 'Atlantic-Ethiopian Continent' a tract of water termed the 'Brazilian Connecting Sea' stretches across South America to the 'Great Pacific Ocean,' and this has a shallow bay invading Brazil, and a deeper bay cutting into the centre of the United States and forming the so-called 'Appalachian Bay.' It was in the 'Brazilian Sea' that the South American Devonian beds accumulated. A great 'Southern Continent' bounded this sea on the west, and extended across the South Pacific to New Zealand and north of it. Such is Katzer's schematic restoration of land and sea areas in the southern hemisphere in connection with his study and comparison of the South American Devonian. In so far as it applies to the Bokkeveld fauna all the evidence available goes to support its main outlines. Haug's discoveries in the Sahara may require a more direct connection of the Cape area with North Africa, and Central Africa is almost unknown geologically. The route by which the Coblenzian types of Western Europe found their way to the south and west is not so clear, as the 'Atlantic-Ethiopian Continent' would offer an insuperable barrier to a direct migration. Haug (32, p. 694) attacked the problems of palæogeography from the consideration of the position of the geosynclinals, and was led likewise to place a great land barrier (the 'Africano-Brazilian Continent') to the north of the sea in which the Devonian of South Africa and South America were deposited. But these views were published prior to the Saharan discoveries. Schwarz (33) has called Katzer's 'Atlantic-Ethiopian Continent' by the simpler name of 'Flabellite Land,' after the characteristic fossil *Leptocœlia flabellites*.

Frech (26, p. 239) has proceeded on the view that the Bokkeveld beds are of Lower Devonian age, and his restoration of the ancient geography differs somewhat from Katzer's. By the insertion of a narrow strait cutting across Katzer's 'Atlantic-Ethiopian Continent' and separating his own 'Indo-African Continent' from his 'North Atlantic Peninsula' (which corresponds more or less with the northern half of Katzer's aforesaid continent) he brings into connection the West European and South African faunas, which Katzer failed to do. The latter's 'Indian Connecting Sea' to the east of the present African continent finds no place in Frech's map, and we notice, too, the practical absence of the great 'Southern Continent' in the South Pacific, and the consequent merging of the 'Brazilian Connecting Sea' into the main Pacific Ocean. The 'Northern Helderberg Sea' of Frech's map corresponds somewhat to Katzer's 'Appalachian Bay' and passes southwards into the 'Southern Helderberg Sea,' which is represented as covering most of South America. A 'South Atlantic Island' more or less prevents a direct communication between the Cape and the Falkland Islands.

The restoration of past geographical conditions is not as a rule satisfactory, and such maps must be largely speculative, the real causes which determined the differentiation of the faunas being rarely ascertainable. The habit of imagining the existence of land barriers to account for differences in contemporaneous geological marine faunas may be carried too far, particularly in dealing with the distribution of molluscan faunas indicating water of moderate depths. The factors which are responsible are much more subtle and intangible. The present arrangement of marine zoological provinces round the coasts of the Atlantic affords a lesson and a warning. Apart from lithological characters of the beds and other geological considerations, the mere faunistic difference of contemporaneous beds is quite compatible with their deposition in the same ocean basin either along continuous coastlines or on opposite shores with open sea between them and without any land barriers to separate them. Differences of climate are frequently invoked to explain such difficulties, but we now know from marine biological research that climate is only one factor, and not by any means the most important one, in determining the characters and distribution of marine littoral faunas. Walther (30) has especially laid stress on the importance of bearing this in mind in dealing with the fossil contents of marine formations, and the modifications of Neumayr's Jurassic theories which recent work in South America, the Arctic regions, and elsewhere has necessitated, emphasise the wisdom of allowing for the action of other factors.

CONCLUSIONS.

Summing up the results of the foregoing survey we are led to the following conclusions:—

1. The Bokkeveld fauna is more closely allied to that of the Devonian of South America than to that of any other area.

2. This southern Devonian fauna is marked by the special development of certain peculiar subgenera (*Anchiopella* and *Metacryphaeus*),

and by the predominance of other genera or groups (e.g. *Palæoneilo*, *Nuculites*, ribbed Centronellids, Bellerophontids of the *trilobatus* group), as well as by the absence or extreme rarity of many others and of certain groups (cephalopods, corals, bryozoans).

3. The affinities of this fauna are much closer to that of the Devonian of North America (eastern parts) than to the West European type.

4. The palæontological evidence tends to show that the Bokkeveld fauna is rather Middle Devonian than Lower Devonian when compared with North American faunas.

5. The European elements of the Bokkeveld fauna, on the other hand, have the facies of the Rhenish Lower Devonian (Coblenzian) rather than of the Middle Devonian of Western Europe.

6. These European elements, though generally recognisable in the southern fauna, are more strongly represented in South Africa than in South America.

7. The Bokkeveld fauna has a certain individuality of its own owing to the presence of certain peculiar genera (e.g. *Typhloniscus*) and species, in spite of its close relations to that of the South American Devonian.

8. The Bokkeveld fauna contains the following elements, in their order of relative importance and abundance: (1) species and groups identical with or allied to South American Devonian types; (2) species identical with or allied to Middle Devonian types of North America, including many in the first category; (3) species allied to Coblenzian species of Western Europe; (4) species or types peculiar to South Africa or with remote and obscure affinities.

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Corrigendum.—On p. 170 in the April number of this Magazine the species of *Phacops* mentioned as "a form compared with *Ph. rana*, Green . . . . by Kayser," has been described by Mr. I. Thomas (10, p. 16) as a new species under the name of *Ph. argentinus.*

REVIEWS.

I.—New Memoir and Map of the Geological Survey of Ireland.

The Geology of the Country around Limerick. By G. W. Lamplugh, F.R.S., S. B. Wilkinson, J. R. Kilroe, A. McHenry, M.R.I.A., H. J. Seymour, B.A., F.G.S., and W. B. Wright, B.A., F.G.S. 1907. 9½″ × 6″; pp. vi + 120, with 7 photographic process plates and 11 figures in text. Price 2*s*. [In explanation of map 1 inch to 1 mile ($\frac{1}{63360}$), Limerick District (Drift Series), parts of Sheets 143 and 144, colour-printed, published 1906, price 1*s*. 6*d*.]

THE area comprised in the map and described in the memoir amounts to 216 square miles, and includes Castleconnell, Caherconlish, Adare, and of course Limerick. The river Shannon enters the area on the north-east, bends westward, and flows for 20 miles generally westward.

The solid geology is described by Mr. J. R. Kilroe. The oldest rocks shown are Upper Silurian Llandovery beds, close to the northern margin of the map. They are calcareous shales and grits and clay rocks, and have been intensely affected by pre-Carboniferous compression, which produced cleavage and here and there violent contortion along nearly east and west axes. The highly contorted and fractured Silurian beds were subjected to extensive denudation prior to the deposition of Upper Old Red strata, their upturned truncated edges forming the floor upon which the latter were laid down. The Upper Old Red Sandstone is usually a coarse yellow quartzose grit, sometimes conglomeratic and sometimes calcareous, and often having greenish sandy shale partings between the beds. It overlies the Silurian rocks near the north-west margin of the area, and forms the foothills of the Slievefelim range at the eastern margin. It conformably underlies the Lower Carboniferous series, but fossil evidence of its age is wanting.

The Carboniferous Lower Limestone Shale is about 50 feet thick, and forms a narrow band, 8 miles long and almost wholly concealed by drifts, to the south of the Old Red Sandstone, near the northern margin and to the west of it in the Slievefelim district.

The overlying Lower Limestone consists in the lower portions of earthy limestone, in parts shaly, passing up into blue and grey limestone, much purer in quality than the lower strata, containing some chert, and being in certain places dolomitic.

It forms a strip ¾ to 1¼ mile wide (the northern limb of a syncline), overlying the Lower Limestone Shales in the north of the map area, forms an anticline over 2 miles broad in the south-eastern district, and occupies large areas on the east and west sides of the district.

The Middle and Upper Limestones are undistinguishable in this district. A band of cherty beds from 20 feet to 150 feet in thickness has been taken as characterising the incoming of the upper series, which includes the Middle and Upper Limestones. Large contemporaneous masses of igneous origin frequently come in just above the cherty beds. Over these cherty beds or, where present, over the igneous rocks are dark-blue, sometimes black, fetid, argillaceous limestones, that generally have thin shale partings between the beds; these are in some places succeeded, as we ascend, by another group of igneous rocks, and these again by blue compact limestone. The Upper and Middle Limestones, including the associated trappean rocks, are calculated to be about 2,000 feet thick. They occupy a great synclinal basin with minor anticlines in the centre of the area.

In the south-east corner of the area occur two series of beds, which were originally regarded as Coal-measures, but which correspond in stratigraphical position and approximately in age to the subdivisions that have been correlated elsewhere in Ireland with the English Yoredale Shale and Millstone Grit respectively and are now mapped as such.

Within the limits of the present sheet occur three large areas of igneous rocks, mainly of volcanic origin, and some seven smaller outlying areas. Viewed in association with similar rocks which appear throughout an area extending some twenty miles to the south-eastward, they render this region, in the words of Sir A. Geikie, "one of the most varied and complete of all the Carboniferous volcanic districts of Britain."

The igneous rocks described are Volcanic Tuff and Ash, Basalt and Dolerite and Trachytic Rocks (Orthophyre [Orthoclase porphyry] type). It has been generally held that the basaltic layers of Carrigogunnel and Boughilbreaga are contemporaneous and 'interbedded' with the tuffs of these localities. Mr. Kilroe cites evidence in favour of the view that they are intrusive. If, as is possible, the sills are of the period to which the great basic mass south of Ballybrood belongs, they would be more recent than the Millstone Grit, but how much more recent there is no evidence to show.

The Glacial Drifts. While most abundantly developed on the lower ground, the glacial deposits are found overlying the solid rocks in every part of the district.

Unstratified boulder-clay, the direct product of the ice-sheet, constitutes the most prevalent type of glacial drift, but there are extensive masses of stratified drift consisting of sand and gravel assorted and deposited by water. The two varieties of Boulder-clay most prevalent in the present map are derived respectively from the Carboniferous Limestone and from the Old Red Sandstone.

Boulders of Carboniferous Limestone are more abundant than those of any other rock, and are so large and so numerous that it is sometimes difficult to decide from a small outcrop whether the limestone is in place or is part of a shifted block. Old Red Sandstone and the Carboniferous volcanic rocks likewise contributed their quota of boulders. Boulders of rocks entirely foreign to the district are of comparatively rare occurrence. The most notable are the blocks of granite recognizable as that which occurs in place on the north side of Galway Bay.

From the evidence afforded by the glacial scratchings on surfaces of rock and by the direction of transport of boulders, and other material incorporated in the drift, it is clear that the ice by which the country was overwhelmed had a general movement, from approximately north-west to south-east, though with many local deflections due to the irregularities of the ground. It is important to note that this direction is transverse to the Shannon, and is, moreover, not toward the western coast but trends somewhat inland. Post-Glacial deposits, consisting of Old River Gravels and Peat, complete the series of rocks of the district.

In the "Notes on the Soils and Subsoils," which are presumably intended for farmers, it seems to me unreasonable to give dimensions in millimetres and centimetres and weights in grams until the metric system is made compulsory in the British Isles.

At the foot of the map a longitudinal section from the Silurian hills on the north-west across the great syncline of Carboniferous rocks with a minor anticline in it south-east of Limerick, and then traversing between Cahernarry and Knockroe an anticline of Lower Limestone overlain on either side by thick beds of basalt and volcanic ash, extends to a point one mile west of Ballybrood House. The abrupt right angle drawn in the centre of the anticline and the sharp zigzags in the Silurian rocks look rather unnatural. B. HOBSON.

II.—IGHTHAM: THE STORY OF A KENTISH VILLAGE AND ITS SURROUNDINGS. By F. J. BENNETT; with contributions by W. J. LEWIS ABBOTT, E. W. FILKINS, BENJAMIN HARRISON, J. RUSSELL LARKBY, J. SCOTT TEMPLE, and H. J. OSBORNE WHITE. Small 4to, cloth; pp. viii + 158, with 40 illustrations, maps, and plans. (London: The Homeland Association, Ltd., 1907.)

IGHTHAM and the surrounding districts are sufficiently rich in geological and archæological interest to deserve the distinction of a monograph. Such a work might have been expected long ago from Mr. Benjamin Harrison, with his unrivalled local knowledge. But Mr. Harrison, though unsparing of his pen in correspondence, exercises excessive self-restraint in committing manuscript to the printer; and it has therefore been left to others to take up the work. When Mr. Bennett, on retirement from the Geological Survey some years ago, settled at West Malling, he became an enthusiastic student of the neighbouring country; and feeling, after a while, that Ightham needed its historian, he determined personally to supply the want.

As the result of several years' work, aided by friends whose assistance is freely acknowledged, he has just contributed to "The Homeland Library" an interesting volume, which will be welcomed by the student of geology and archæology as a convenient guide to a locality of exceptional attraction.

In Mr. Bennett's close study of the district he found it desirable to undertake a re-survey of the Drift on the 6-inch map. This detailed work led him to recognize a special type of deposit, which he distinguishes as 'scarp drift.' Occurring as terraces at the foot of the Chalk escarpment and running up the coombes, it is composed largely of pellets of chalk, passing into a loam, and is regarded by the author as the relics of the great denudation of the Chalk scarp. The classical problem of the denudation of the Weald naturally claims discussion at some length. Not satisfied, like many others, with the adequacy of Ramsay's views, the author invokes with Prestwich the aid of glacial action; but, after all, considers that the problem remains unsolved, since none of the theories put forward completely meet the case. "In our opinion," says Mr. Bennett, "the various causes of the denudation of the Weald are still to be sought for, and the question may still be considered to be an open one."

To explain the formation of the deep gorge of the Shode, the author supposes that subaerial denudation was assisted by subterranean erosion. He holds that the underground flow of water in the Hythe Beds, pent up between the Atherfield Clay below and the clayey Sandgate Beds above, would effect much erosion; and that when the stream, in working downwards, cut any water-bearing joints the released water might rush up by hydrostatic pressure, as in an artesian well, thus materially assisting the denudation, whilst subsidence would be a contributory factor in the formation of the valley.

The Eolithic question, which has done so much to make Ightham famous, is fully dealt with; but it is doubtful whether many anthropologists will care to follow the author in his recognition of a yet earlier 'Lithic period.' Mr. Larkby contributes a chapter on the development of flint implements, whilst Mr. Bennett describes the palæolithic rock-shelters at Oldbury and the megalithic remains in neighbouring districts. Mr. Scott Temple writes on many of the historical monuments, and Mr. Filkins describes the famous Mote House, whilst the rather curious subject of gravestones is dealt with by Mr. Bennett.

One of the most interesting sections of the work is Mr. Lewis Abbott's description of the bone-bearing fissures in the limestone of the valley of the Shode, in which he summarizes his remarkable researches, so well known to geologists. Incidentally he remarks that he still has probably 20,000 relics awaiting examination. Finally, Mr. Osborne White contributes an appendix on the Chalk of Ightham.

It remains to add that the work is well illustrated, mostly from photographs. A portrait of Mr. Harrison appropriately forms the frontispiece, whilst several plates of stone implements represent specimens in the "Harrison Collection," now in the County Room of the Maidstone Museum, where they have been photographed by Mr. Elgar, the sub-curator.

III.—VOLCANOES.

LES VOLCANS DE LA TERRE. Par ÉLISÉE RECLUS. Premier Fascicule. 1906. Société belge d'Astronomie, de Météorologie, et de Physique du Globe, Brussels.

THE work of which the title of the first part is given above is the outcome of a proposal made by the late M. E. Reclus to publish a work descriptive of the volcanoes of the world. The complete work is to comprise 1,500 pages and to be illustrated by maps and figures. The subscription price is 25 francs for an ordinary copy, and 50 or 100 francs for éditions de luxe on superior paper.

The first part consists of 168 pages (10 × 6½″), and is devoted to "Asie Antérieure." The first chapter (pp. 11 to 30) deals with Persia. After a short sketch of the physical features of the country, the chief volcanoes, such as Demavend (of which a map and geological section, after Stahl, are given), etc., are described, and the chapter concludes with a bibliography of books, papers, and maps.

The method followed in succeeding chapters is similar. The second chapter (pp. 31 to 73) treats of Armenia, and in this chapter Ararat is described under the unfamiliar Armenian name of Masis, and a map of Ararat and Ala-Göz is given. Dr. Felix Oswald's work on the geology of Armenia appeared too recently to be included in the bibliography.

Chapter iii (pp. 75–98) deals with Syria, Chapter iv (pp. 99–130) with Asia Minor, Chapter v (pp. 131–163) with the Caucasus.

The comment one feels disposed to make is that the descriptions are rather those of the traveller than of the geologist. That of Elbruz (Caucasus) is rather meagre. The name of the rock of which its lavas consist is not mentioned. All that is said of them is, "Ses coulées sont formées d'une roche à pâte noire semi-vitreuse contenant de gros grains de quartz et des cristaux d'oligoclase et de pyroxène; un peu de biotite [misprinted biolite] et de magnétite s'y mêle." This is a mangled quotation from the Guide des Excursions of the International Geological Congress of 1897 (St. Petersburg). There is no excuse for so vague and unsatisfactory a description of the lavas of Elbruz, since Dr. A. Dannenberg published in Tschermak's Mineralogische und Petrographische Mittheilungen, vol. xix (1900), pp. 218–242, his "Beiträge zur Petrographie der Kaukasusländer," in which a full account of the hypersthene amphibole dacite lava of Elbruz is given. In the second part of Dr. Dannenberg's paper in vol. xxiii (1904) of the same periodical a pyroxene andesite from Ala-gös in Armenia is described, though in Reclus' description only obsidian, scoria, basalt and pumice, and artificial tombs of trachyte are mentioned. Interesting as this great work on volcanoes is, more attention must be paid to geological structure and composition of volcanic products if the work is to have scientific value. The names of collaborators are not given. A competent geologist and petrographer should be among them to check the loose petrographical names often given by travellers. It is as important that species should be correctly named in the case of rocks as in that of fossils.

B. HOBSON.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

March 27th, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communications were read:—

1. "On the Southern Origin attributed to the Northern Zone in the Savoy and Swiss Alps." By Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.G.S.

Professor Lugeon, with some other eminent Continental geologists, explains certain peculiar flat folds, the higher of which sometimes project considerably beyond the lower, in the more northern sedimentary zone of the Swiss and Savoy Alps, by supposing that to no small extent the strata have been thrust forward from an original position south of the watershed of the Pennine-Lepontine Alps; overriding, as they advanced, their crest and that of the Oberland (neither having then attained its present altitude). This pressure was produced by the greater thickness of deposits of Mid-Tertiary age, speaking in general terms. Professor Sollas, in concluding a very interesting and suggestive paper on some experiments with cobbler's wax, published in the last volume of the Quarterly Journal of the Society, p. 716, suggests that the results are favourable to the views of the Lausanne professor.

The author takes exception to some of the cases, especially two to the east of the Simplon Pass, which are adduced by Professor Lugeon in support of his hypothesis, pointing out that he has confused an ordinary with a crystalline limestone, and merely schistose slates with true crystalline schists. But, without going into the details of sections, he shows from general reasoning that both the kind and the amount of transport, postulated by Professor Lugeon, introduce serious mechanical difficulties. Sediments are assumed to have been transported from (say) near Ivrea to the northern margin of the Alps on either side of the Rhone valley below Martigny; that is, to have travelled something like 75 miles. As the average thickness of the Secondary and older Tertiary strata in this part of the Alps can hardly exceed 2·5 miles, we can form a general idea of the problem by drawing an oblong 30 times as long as high. Then, material at one end (southern) has to be squeezed across obstacles to near the other, by piling a wedge-like mass of sediment on a southern prolongation of the oblong, the thin end of which mass may perhaps trespass a little on the northward side of the original southern boundary.

After discussing the problem in some detail, the author shows that in Professor Sollas's experiments there was, at the beginning of loading, a wedge instead of an oblong; the distance to be traversed was six times the maximum thickness of the (supposed) sedimentaries, instead of about 30 times; and the slope of the added mass was about double that which, in the Alpine case, is supposed to be the sole cause of the movement. Lastly, in the case which presents by far the greater difficulties, the material is limestone and shale instead of cobbler's wax. The author maintains that Professor Lugeon's hypothesis receives no real support from Professor Sollas's experiments, and involves mechanical difficulties which are practically insuperable.

2. "The Coral Rocks of Barbados." By Professor John Burchmore Harrison, C.M.G., M.A., F.I.C., F.G.S.

The results of the author's extended, and in many places detailed, re-examination of the coral rocks in the southern half of Barbados, give no support to Dr. J. W. Spencer's theory of the existence of strata of the "Antigua Formation" in that island. It is now shown that a certain knoll, whence Dr. Spencer collected corals which in his estimation proved that it and other parts of the coral rocks were of Oligocene age, is in part made up of corals which, as stated by Professor J. W. Gregory, "certainly show no evidence of any age greater than the Pleistocene." The author has failed to find any signs of the widespread formation, described in Dr. Spencer's paper as extending from Mount Misery to near Ragged Point, a distance of about 11 miles, and dipping south-eastward at from 12° to 20°. Such a formation would be about 15,000 feet thick; while the facts that nowhere in the island does the combined thickness of the limestone and of its basal or Bissex Beds exceed 280 feet, and that the limestone is not traversed by faults, are fairly conclusive evidence of the non-existence of such a formation. This dip is referred to the action of landslips in some cases, and in others to current-bedding. The author's recent investigations have confirmed the statements made and the views expressed by Mr. Jukes-Browne and himself in the notes published in the Geological Magazine for December, 1902, p. 550.

CORRESPONDENCE.

SANDSTONE PIPES IN CARBONIFEROUS LIMESTONE, ANGLESEY.

Sir,—In the Geological Magazine for January, 1900 (p. 20), was published a paper (read and discussed at the Dover Meeting of the British Association in 1899) on Sandstone Pipes in the Carboniferous Limestone of Anglesey, in which I showed that they formed a part of the Carboniferous Series, and were evidently due to some unusual kind of contemporaneous erosion.

In November last Professor W. H. Hobbs, Secretary of the American Seismological Committee, wrote to me suggesting that these pipes might be the 'craterlets' of Carboniferous earthquakes, produced by disturbance of underground waters in the same way as those of the Calabria, Charleston, and other shocks of recent times. Some of those of Calabria are figured in Lyell's Principles. The Comte de Montessur de Ballore, to whom Professor Hobbs asked me to send photographs, has concurred, after some correspondence, in this explanation.

Both authors will discuss the phenomenon, together with certain kindred ones, in works now in the press, and as these will be published outside this country the object of this letter is to invite the attention of British geologists to this very curious and most original suggestion.

EDWARD GREENLY.

P.S.—Perhaps I might add that the pipes are very near to a zone of powerful faulting, which, though displacing the Carboniferous rocks more than 1,000 feet, was almost certainly a line of movement in much older times. Movement along it, therefore, was very likely going on at intervals during the Carboniferous period itself.

FOSSIL FOOTPRINTS IN THE SECONDARY ROCKS.

SIR,—I am returning to the study of the Triassic footmarks of the Connecticut, and would be glad to correspond with the Officers of Museums with reference to slabs of Ichnites found especially in Great Britain. My experience leads me to believe that the tracks of animals on stone are more abundant than is commonly supposed, and that there is much to be learned from their study. Although rather bulky, a place can be found for them in the Exhibition Rooms, and perhaps exchanges can be negotiated.

C. H. HITCHCOCK,
Curator of the Butterfield Museum, Dartmouth College,
Hanover, New Hampshire, U.S.A.

March 7th, 1907.

CONODONTS IN COAL-MEASURE STRATA.

SIR,—Not long ago I sent you a notice of the occurrence of marine fossils in the Upper Coal-measures (Scotland). From the same bed I have now to record the finding of a few Conodonts, the determinable species being *Centrodus lineatus*, Pander, and *Polygnathus* (*Gnathodus*) *Mosquensis*, Pan. Both these forms were found by Pander, of Russia, in the Mountain Limestone of Moscow, and they occur in both the Upper and Lower Carboniferous Series of Scotland. *C. lineatus* has been got in the Devonian rocks of Canada and Carboniferous of Ohio. The list of fossils from this bed is as follows, all the forms being dwarfed except the Conodonts, which could not be made much smaller:—

Productus semireticulatus.
Chonetes Hardrensis.
C. Buchiana.
Athyris ambigua.
Discina nitida.
Lingula mytiloides.
Pecten, ribbed.
Posidoniella vetusta.
Murchisonia striatula.
Dentalium?
Nautilus?
Polyzoan, badly preserved.
Cladodus.
Coprolites and fish-remains.
Plants and vascular tissue.
Centrodus lineatus.
Polygnathus Mosquensis.

The position of this marine bed is pretty well up in the Coal-measure Series, probably a short distance above the Craigmark Ironstone, Craigmark Glen, Dalmellington.

J. SMITH.

DYKES, DALRY,
AYRSHIRE.

OBITUARY.

CARL LUDOLF GRIESBACH, C.I.E., F.G.S.

BORN DECEMBER 11, 1847. DIED APRIL 13, 1907.

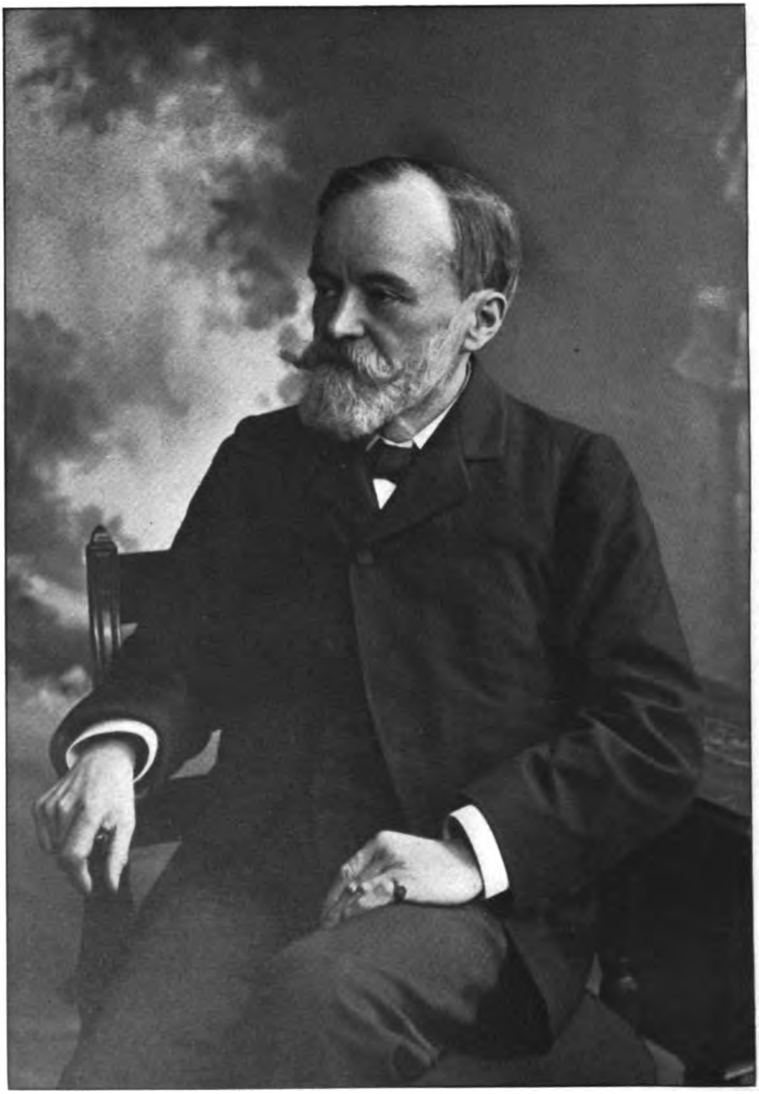
IT is with deep regret that we record the death of Mr. C. L. Griesbach, C.I.E., F.G.S., late Director of the Geological Survey of India, from July 17th, 1894, to February 24th, 1903.

Mr. C. L. Griesbach was born in Vienna on December 11th, 1847, and was the eldest son of Mr. George L. Griesbach, of Zobelsberg, a British subject. Carl was educated at the University of Vienna, and was for some time engaged upon the Geological Survey of Vienna, where he acquired his experience as a field geologist and palæontologist. He commanded a German scientific expedition to East Africa 1869–70, and on his return resided in London from 1871 to 1878, where he was engaged in scientific work; he was also a most accomplished artist. He communicated an important paper "On the Geology of Natal in South Africa" to the Geological Society (see Quart. Journ. Geol. Soc., vol. xxvii, 1871, pp. 53–71, with many illustrations prepared by himself). In 1878 he was appointed Assistant Superintendent to the Geological Survey of India, and joined in Calcutta the same year. He passed through various grades of promotion from 1880 to 1884. From 1884 to 1886 Mr. Griesbach was employed on the Afghan Boundary Commission, with the grade of Deputy Superintendent, and was raised to first grade Superintendent in November, 1886. He was created a Companion of the Indian Empire in February, 1887. From January, 1888, to July, 1889, his services were placed at the disposal of H.H. the Amir of Kabul, and he was made a Superintendent in 1889, and—on the retirement of Dr. William King, F.G.S.—Director of the Geological Survey in 1894.

When resident in London he served as an Officer in the Royal London Militia, now the 6th Battalion Royal Fusiliers, and has since been retired with the rank of Lieutenant-Colonel.

A list of twenty-six scientific papers by Mr. Griesbach will be found in the GEOLOGICAL MAGAZINE for June, 1903, pp. 287–288; also of his special war services in India. Mr. Griesbach, in 1869, married Emma, daughter of the Rev. W. R. Griesbach, M.A., of Millington, Yorkshire, who died in 1892, leaving two children. He has lately resided in Graz, Austria, with his daughter. His only son, Walter, is at Revelstoke, B.C. For the last year Mr. Griesbach has been suffering from thrombosis, and although at times slightly better he succumbed to this malady on the 13th April, at the age of 60.

Mr. Griesbach served for twenty-five years on the Geological Survey of India. He was a Foreign Member of the k.k. Akademie der Wissenschaftlich Wien and numerous other learned societies. He was decorated for the Boundary Commission; received the Afghan medal and clasp, the Burma medal and clasp, the Nishaw-i-Hurmat (Afghan order); H.I.M. the Emperor of Austria-Hungary presented him with the Austrian gold medal in connection with the scientific expedition to the central regions of the Himalayas in 1892. He was elected a Fellow of the Geological Society of London in 1874.



Yours faithfully
H. G. Seeley.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE V. VOL. IV.

No. VI.—JUNE, 1907.

ORIGINAL ARTICLES.

I.—EMINENT LIVING GEOLOGISTS:

PROFESSOR H. G. SEELEY, F.R.S., F.L.S., F.G.S., F.Z.S., F.R.G.S.;

Professor of Geology, Geography, and Mineralogy, King's College, London; Dean of Queen's College, London; Corr. Memb. Inst. Imp. Reg., Geol. Vindob., Acad. Nat. Sci. Philad., Soc. Phil. Ebor., Soc. Imp. Sci. Nat. Hist. Mosq. Soc., Senckenb. Natur. Gesells. Frankf.; Corr. Hon. Memb. S. African Phil. Soc.; Memb. Corr. Acad. Imp. Sci. St. Petersburg.

(WITH A PORTRAIT, PLATE XII.)

"*The story of our life from year to year.*"

IN presenting to our readers a brief notice of the life and work of Professor Seeley, one of the most eminent of Vertebrate Palæontologists, we feel that we are offering but a scant tribute to one who has for more than thirty years occupied a leading position in the world of science. He is not only an accomplished teacher in Geology and the allied sciences in the University of London, but has long been recognized as a distinguished worker in the fields of Zoology and Comparative Anatomy. His investigations into the Fossil Reptilia of the Secondary period, and especially his remarkable researches in the Anomodont Reptilia from the Trias of South Africa, are already classic and unsurpassed. His purely geological work in the field has also made substantial contributions to our knowledge of the strata in the South of England.

In early years Harry Seeley found in the London Library and the lectures of E. W. Brayley, F.R.S., on Terrestrial Magnetism, his first introduction to Physical Geology. Lyell's "Principles of Geology" kindled an enthusiasm for observation, which afterwards secured his succession to the Chair which Charles Lyell had held in King's College as well as the Lyell Medal from the Geological Society, founded by that great master. But his scientific career appears to have been determined as a consequence of an old regulation, long since abrogated, under which he was admitted at the age of 17 as a Reader in the British Museum Library. His studies at first tended towards Anthropology, till the help of Professor Rymer Jones in Zoology, and afterwards of Dr. S. P. Woodward in Palæontology and of John Edward Gray in geographical distribution of animals, laid the foundation of a geological tendency, which was developed by the lectures of the Professors of the Royal School of Mines, and matured by field-work among the strata of the South-East of England. The personal friendship of the scientific men of London, ever anxious to help a thoughtful student, tended to develop a broad concrete practical knowledge.

After three years of study in the galleries of the British Museum literary work took Seeley to Cambridge. Here Adam Sedgwick visited him, and invited him to become his assistant. In later years Sedgwick wrote in a printed letter—"In youth you had a reputation for genius and skill in some departments of Natural History. It was that reputation which made me seek you out and secure your co-operation as my assistant and fellow-labourer."

Seeley at once turned his attention to the local geology of the Cambridge district, and had the advantage of finding the coprolite diggings for the manufacture of superphosphate of lime, opening up an astonishing fauna in beds at the base of the Chalk, which became known as the Cambridge Greensand. He had attended Sir Richard Owen's lectures on Palæontology in London, and found this knowledge the means of dealing with the vast accumulations of vertebrate fossils which occurred in association with shells, corals, and crabs in that deposit.

His work with Sedgwick was of a kind that took the old master and the young naturalist together on many geological excursions, not only to verify new work in the local geology, but to examine the sections over again in the Isle of Wight, Isle of Sheppey, and other localities. The practical field teaching at Cambridge was soon placed in Seeley's hands, and owing to Sedgwick's illness he was called upon to lecture, often at a moment's notice, upon the subject for the day in the Professor's course. This led Mr. Seeley to prepare himself for emergencies, and to visit the important geological localities in Wales and Devon and the east and west of England, where he commonly travelled, compass in hand, sketching the physical features of the country in notebooks when the hammer was not in use.

In these days the volumes of catalogues of the Woodwardian Museum which deal with the fossil Reptilia and Ornithosauria were prepared, and printed by the University Press. For ten years his work as assistant naturalist in the Woodwardian Museum led to a series of publications in 1864 on the affinities between reptiles and birds, and to the recognition in 1869 of a bone in the British Museum which had been regarded as the tympanic bone of *Iguanodon*, as the vertebra of a new type of animal named *Ornithopsis*, the forerunner of a large order which includes the *Diplodocus* as its most conspicuous member.

About the time when the Cambridge catalogues were published in 1870, his old friend John Edward Gray invited him to enter the Zoological Department of the British Museum, and Prof. Huxley offered a recommendation for the Geological Survey. But Seeley was anxious to settle in London and avail himself of the opportunities for work in the Museums and Libraries. Some two or three years were spent in lectures and literary work. In 1876 Seeley was appointed to the Chair of Geography in King's College. His travels had enabled him to become practically acquainted with both the processes and materials used in a large number of industries, and his lectures on Economic Geography were for many years a systematic discussion of the use of natural products by man, and of man as affected by geographical distribution. And in this work field-studies in physical geography were the basis of practical teaching, which was afterwards illustrated to his classes in the field. Some of these lectures given at the Royal Institution are printed in the first volume of Phillips's Geology, and others have been delivered at the request of the Gilchrist Trust in many towns in the British Islands. Others, again, on "Physical Geography in relation to Public Health," were communicated to the College of State Medicine.

Professor Seeley had for some time taken an active interest in the higher education of women, and in 1876 was chosen Professor of Geography and Geology in Queen's College, London,[1] and five years later succeeded to the office of Dean, on the resignation of Sir Henry Craik. Here under his teaching and guidance a large number of pupils have been trained, not only in the subjects of the curriculum, but in lectures on current topics of geological interest.

On the occasion of the Jubilee of Queen's College in 1898, on the visit of Queen Victoria, Prof. Seeley, as Dean, was presented to Her Majesty.

In 1890 he was invited to the arduous duties of Lecturer on Geology and Mineralogy in the Royal Indian Engineering College at Cooper's Hill, and in 1891 was appointed successor to Professor P. M. Duncan. Here he found an earnest body of men who soon listened to him with an affection which grew year by year, and so led them on to attain a high standard of proficiency in their work. The Indian Government supplied him with rocks, fossils, and maps from India; and geological knowledge was demonstrated in the field in short and in more extended excursions. Professor Seeley endeavoured to teach by taking his students through the methods of research, as distinct from giving them the results of research; and this may be the secret of the interest which his lectures kindled.

It was only on the retirement of the Rev. Professor Wiltshire, D.Sc., from office at King's College that the Chair of Geology and Mineralogy was conferred on Professor Seeley in 1896. At this time the teaching University was getting into work, and the subject which hitherto had been a part of the course in Engineering in King's College now became expanded to meet the wants of Civil Engineers and Mining students; while in the Faculty of Science complete courses, theoretical and practical, were arranged for the examinations of the University of London. The geological course which had been given in the Ladies' Department of King's College in Kensington Square for ten years was now relinquished. Excellent new laboratories and lecture-rooms for Geology were built in King's College, and fitted with petrological and other apparatus for a modern school of the science and for research.

During the ten years 1880–90, for which lectures were given for the London Society for the Extension of University Teaching, the most interesting result of endeavours to secure practical work as a part of the course was the establishment of the London Geological

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[1] Queen's College, London, was founded with the approval of Her late Majesty Queen Victoria, who always presented a scholar to the scholarship she had founded.

Field Class. Professor Seeley has conducted excursions week by week with this Society of old pupils for twenty-one years, in the summer. It has endeavoured to provide for the whole of London a knowledge of the rocks, as the reward for each student's personal observation. Some record of the earlier teaching is preserved in the "Handbook of the London Geological Field Class," 1890. And now it has borne fruit in the recognition by the University of London of Field Teaching as a necessary condition for graduation in Geology.

Although strongly opposed in earlier years to all examinations which were not co-ordinated with teaching, he has taken part in the work of the University of London as a member of Boards of Studies in Geology, Civil Engineering, Geography, Mining, Agriculture, and Zoology, and has acted as Examiner in Geology and Zoology.

It is impossible to separate a life's work of teaching from the acquisition of new knowledge which could be imparted. Many of the British strata were followed by Seeley along their outcrops in the manner of the early masters, and enough done in the North of France, Belgium, Holland, Germany, Austria, Switzerland, and Russia to impart a distinct tone to his interpretations of many aspects of the science. An accomplished palæontologist, he has used every available museum to trace the variations in the faunas of the geological deposits as they extend through Europe, as a means of estimating their relation to the fossils of more distant regions. From about 1875, when he visited the petrological districts of the Southern Eifel, the Siebengebirge, and Eastern Rhine, and worked over the collections at Heidelberg, began the accumulation of that experience in petrology which took practical form in the new edition of Phillips's Geology, 1884, undertaken with Robert Etheridge as a personal tribute to the work of a former King's College Professor of Geology.

Studies were limited by exigencies of time. The fossil Reptiles which had led to work at Cambridge took him in after years far afield. The Pterodactyles and other types were sought out in the Highlands of Bavaria, and in the Museums of Munich, to which Zittel gave exceptional facilities, Bonn, Tübingen, Stuttgart, Banz, and Haarlem. The Cretaceous reptiles of Gosau led to a residence for some time in Vienna, in the study of remains submitted to him by Professor Suess which were obtained in almost as complete dissociation as those of the Cambridge Greensand. He worked through all the Lias and Trias reptiles in the museums of Germany.

In 1889 Professor Seeley conceived the idea of examining the evidence of the organization of the Anomodonts. The Royal Society supported him, not only with a grant of £200 towards the expenses of travel, but by more important recommendations through departments of the Government. The results of a first visit to Russia appeared in a reconstruction of *Deuterosaurus* and *Rhopalodon*. In the summer of the same year he visited Cape Colony, but most of the important specimens collected had already been sent to Sir Richard Owen, and it was only by traversing the colony that the geological horizons of the fossils could be determined, and new materials found. His effort was aided by the co-operation of Mr. Thomas Bain, Irrigation Officer, who was deputed by Sir Gordon Sprigg to accompany him.

Professor Seeley, in the first instance, explored the Lower Karroo rocks and found the *Pareiasaurus*, and obtained one skeleton practically complete. He then examined the Middle Karroo or Dicynodont beds, but although many interesting reptiles were found no complete skeleton of *Dicynodon* occurred. Further north, at Burghersdorp, he established a friendship with Dr. Kannemeyer, which has led to the discovery of interesting reptiles, and at Aliwal North Mr. Alfred Brown placed in his hands types, which Mr. Brown has presented to the British Museum. Near Queenstown the important skeleton of *Cynognathus* was extracted from the rock, and the skulls of *Gomphognathus* were collected. Having made a circuit of the colony after visiting Kimberley he came over the Katberg, accompanied by Dr. Atherstone, to Grahamstown, where several new reptiles awaited examination. By 1895 the more typical of these reptiles were figured in the Transactions of the Royal Society, but the materials awaiting publication are varied and not unimportant, and likely to occupy all his available leisure for some years. The described specimens have been presented to the British Museum by their discoverer, who has watched over the removal of the matrix from the bones, a task still in progress.

Professor Seeley was elected a Fellow of the Geological Society in 1862, when his godfathers were Adam Sedgwick, William Whewell, and William Hopkins. In 1872 he married Eleanora Jane, only daughter of William Mitchell, of St. George's Lodge, Bath. Mrs. Seeley has travelled with her husband in Western Europe, and assisted in the measurements of specimens in many foreign museums and in his work generally. In 1879 he was elected a Fellow of the Royal Society; in 1902 a Member Correspondant of the Imperial Academy of Sciences of St. Petersburg; and in 1905 a Fellow of King's College, London.

LIST OF SCIENTIFIC PAPERS BY PROFESSOR H. G. SEELEY.

1858. "Description of two new species of Chalk Starfishes": Ann. Mag. Nat. Hist., vol. ii, pp. 335–337.

1859–63. "On some Anomalous Fossils from the Upper Greensand of Cambridge": Proc. Geol. Assoc., vol. i, pp. 147–148.

1861. "Notes on Cambridge Palæontology: (1) Some new Upper Greensand Bivalves": Ann. Mag. Nat. Hist., vol. vii, pp. 116–124.

"Notice of Opinions on the Stratigraphical Position of the Red Limestone of Hunstanton": Ann. Mag. Nat. Hist., vol. vii, pp. 233–244.

"Notes on Cambridge Palæontology: (2) On some new Gasteropods from the Upper Greensand": Ann. Mag. Nat. Hist., vol. vii, pp. 281–295.

"Notes on Cambridge Palæontology: (4) Some new Upper Greensand Echinoderms": Ann Mag. Nat. Hist., vol. viii, pp. 16–24.

"On the Fen Clay Formation": Ann. Mag. Nat. Hist., vol. viii, pp. 503–505.

"On the Elsworth Rock and the Clay above it": Rep. Brit. Assoc., pt. ii, pp. 132–133.

1862. "Notes on Cambridge Geology": Ann. Mag. Nat. Hist., vol. x, pp. 97–110.

1864. "On the Fossils of the Hunstanton Red Rock": Ann. Mag. Nat. Hist., vol. xiv, pp. 276–280.

"On the Pterodactyle as evidence of a new subclass of Vertebrata (Saurornia)": Rep. Brit. Assoc., vol. xxxiv, sect., p. 69; GEOL. MAG., vol. i, p. 294.

"On the significance of the Septa and Siphuncles of Cephalopod Shells": Rep. Brit. Assoc., vol. xxxiv, sect., pp. 100–101; Quart. Journ. Sci., vol. i, pp. 760–762.

"On a Section of the Lower Chalk near Ely": GEOL. MAG., vol. i, pp. 150–154.

"A Monograph of the Ammonites of the Cambridge Greensand": [1863]
1864. Quart. Journ. Geol. Soc., vol. xx, pp. 166–167; Ann. Mag. Nat. Hist. vol. xvi (1865), pp. 225–247.

"A Help to the Identification of Fossil Bivalve Shells": Geologist, vol. vii, pp. 44–50.

"*Mytilus spathulatus*, a new Cretaceous species": Geologist, vol. vii, p. 53.

"Cuttings from a Notebook on Chalk Gasteropods": Geologist, vol. vii, pp. 89–93, pl. viii.

"On the Hunstanton Red Rock": Quart. Journ. Geol. Soc., vol. xx, pp. 327–332; Phil. Mag., vol. xxviii, pp. 73–74.

1865. "On *Plesiosaurus macropterus*, a new species from the Lias of Whitby": Ann. Mag. Nat. Hist., vol. xv, pp. 49–53.

"On a new Lizard, with Ophidian affinities, from the Lower Chalk (*Saurospondylus dissimilis*)": Ann. Mag. Nat. Hist., vol. xvi, pp. 145–148.

"On the Literature of English Pterodactyles": Ann. Mag. Nat. Hist., vol. xv, pp. 148–153.

"On two new Plesiosaurs (*P. eleutheraxon*, *P. cliduchus*) from the Lias": Ann. Mag. Nat. Hist., vol. xvi, pp. 352–359.

"On the significance of the Sequence of Rocks and Fossils": Geol. Mag., vol. ii, pp. 45, 262–265.

"On the Fossil Neck Bones of a Whale (*Palæocetus Sedgwicki*) from the neighbourhood of Ely": Geol. Mag., vol. ii, pp. 54–57.

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II.—Fossil Plants from Egypt.

By A. C. Seward, M.A., F.R.S., Professor of Botany, Cambridge.

THE following notes on three fossil plants handed to me by Dr. Hume have been written at the request of Capt. Lyons, Director-General of the Survey Department of Egypt. The material is unfortunately too fragmentary to admit of satisfactory determination; but in view of our ignorance in regard to the former vegetation of Egypt, it is desirable to put on record all available information. Of the three fossils only one is sufficiently well preserved to be referred with any degree of certainty to a genus.

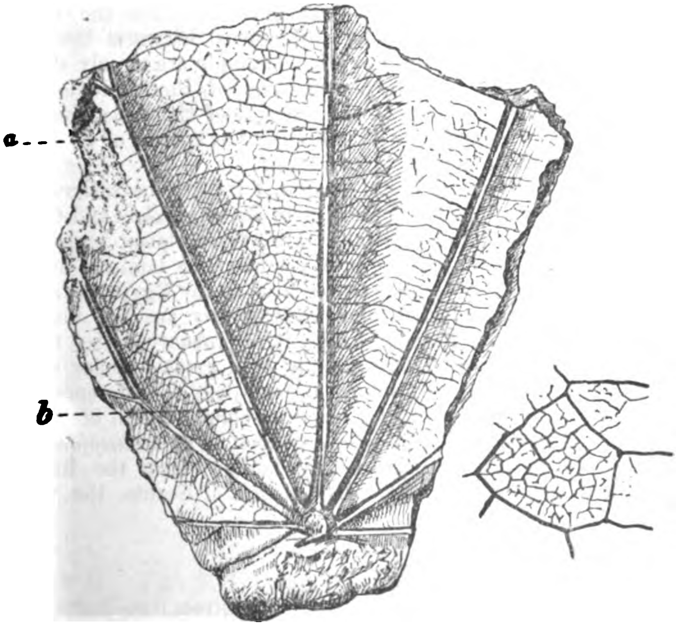

Fig. 1.—*Clathropteris egyptiaca*, sp. nov.

Specimen I. Fig. 1. (No. 10,714.) From the sandstone (Nubian) hills east of Edfu, on the watershed between Wadi Dūm and the large valley flowing east into Wadi Abbad. Latitude approximately 25° N. Collected by Mr. H. T. Ferrar, of the Egyptian Geological Survey.

The specimen is represented natural size in the Figure; it is a portion of a fern frond with very clearly marked venation. From the base of the fragment seven strong ribs radiate through the lamina in a palmate manner; these are represented by grooves with small pieces of the axes shown at *a* and *b*. Two of the ribs are forked near the edge of the lamina. From the main veins slender branches are given off at right angles, the spaces between them being divided into polygonal areas by still smaller veins, which form a reticulum in the meshes of which the ultimate veinlets end freely. (The venation is shown in the enlarged drawing to the right of Fig. 1.) This type of venation is very similar to that of the recent fern *Dipteris*, which occurs in Northern India, the Malay region, and elsewhere; it characterises also certain Mesozoic genera regarded by some authors as members of the family to which *Dipteris* belongs. The Egyptian specimen clearly represents the basal portion of the lamina of a fairly large leaf, of which the main scaffolding consisted of dichotomously branched palmate ribs. A Liassic fern from Steierdorf, originally figured by Andrae as *Protorhipis Buchii*, exhibits a type of venation similar to that shown in Fig. 1. In *Protorhipis* the veins are less spreading and fork at a shorter distance from the base of the lamina; the leaf as a whole is smaller than that of which the specimen before us formed a part. The differences between the species described by Andrae[1] and the Egyptian example are clearly shown by a comparison of Fig. 1 with photographs of the Steierdorf plant published by Zeiller[2] in 1897; other species of the same genus have been figured more recently by Von Richter[3] as species of *Hausmannia* from the Lower Cretaceous of Quedlinburg.

The fragment shown in Fig. 1 should, I believe, be referred to the genus *Clathropteris*. In the fossil genera *Dictyophyllum* and *Clathropteris* the lamina is divided distally into several lobed pinnæ which are coalescent above the petiole into a continuous lamina: it is this continuous basal region which is represented in the Egyptian fragment. The two ferns *Dictyophyllum* and *Clathropteris* are no doubt very closely related, but, as Nathorst[4] says, it is probably better to retain both names on the ground that a study of a great number of forms has convinced him of the existence of well-defined differences. The specimen exhibits the rectangular venation characteristic of *Clathropteris*, but it is noticeable that in a specimen of *C. meniscoides* figured by Goeppert,[5] as in those figured by Zeiller[6] from the Rhætic of Tonkin, and by Nathorst[7] from the Rhætic of Scania, the venation in the basal part of the fronds is much less regular and less rectangular than in Fig. 1. Though it is, as a rule, unwise to institute a new species on so small a fragment, I am disposed to suggest the name *C. egyptiaca* as a distinctive designation for the first example of this genus from the continent of Africa, which seems to differ from the widely distributed *C. meniscoides* in the arrangement of the veins in the continuous part of the lamina. It is, however, possible that the specimen is specifically identical with Brongniart's species *C. meniscoides.* A short account of the geological range of *Clathropteris* and of other members of the Dipteridinæ may be found in a paper by Miss Dale and myself published in 1901.[1] The genus *Clathropteris* occurs abundantly in Rhætic rocks in many parts of the world; it is found also in strata of Liassic age. So far as it is possible to form an opinion as to the age of the rocks from a single fragment of a frond, the probability would seem to be in favour of a Rhætic age. It is, however, impossible to speak with confidence from an examination of the data at present available. Mr. Hume, of the Egyptian Geological Survey, who has read a proof of these notes, writes in a letter dated May 1st, 1907:—"*Clathropteris* was collected in such close relation to the Cretaceous (Campanian) beds that I regard the sandstone in which it was found also as Upper Cretaceous, but we are sadly in need of further evidence." There is no reason why *Clathropteris egyptiaca*, which closely resembles the recent genus *Dipteris*, should not have existed during the Cretaceous period, though such fossils as agree most nearly with the Nubian specimen have hitherto been recorded from lower horizons.

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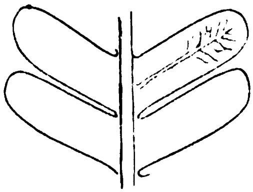
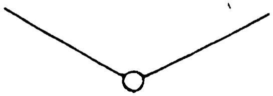
[1] Abh. k.k. Reichsanst., Bd. ii, Abt. 3, 1853.
[2] Rev. Gen. Bot., ix, 1897, pl. xxi.
[3] Beit. Flora Unt. Kreide Quedlinburg, 1906.
[4] Kungl. Svensk. Vetenskaps. Hand., Bd. xli, No. 5, 1906; also ibid., No. 2.
[5] Gattungen foss. Pflanzen, 1841, Lief. 5 and 6, pls. xviii, xix.
[6] Flor. foss. Tonkin, 1902.
[7] Kungl. Svensk. Vetenskaps. Hand., Bd. xli, No. 2.

2





2*a*

Specimen II. Figs. 2 and 2*a*. (No. 10,547.) Found on the side of a hill about 27 miles south of east of Allagi, a station on the Nile between Aswan and Wadi Halfa; speaking roughly, latitude 22° 30′ N.

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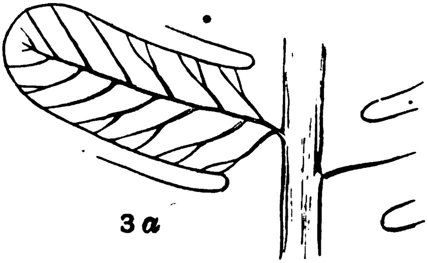
[1] Phil. Trans. Roy. Soc., 1901.

in the desert east of the Nile. Collected by Mr. P. C. A. Stewart, of the Egyptian Geological Survey.

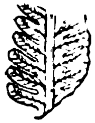
This specimen (10 cm. in length) is part of a compound frond very imperfectly preserved; it is impossible to determine whether it is part of a bipinnate frond or a piece of a pinna belonging to a tripinnate frond.

Incomplete crowded pinnæ are given off from a rachis; these are of uniform breadth, and bear bluntly rounded pinnules 4 mm. in length, attached to the pinnæ axes by the whole of the base (Fig. 2; enlarged rather more than four times). The specimen as a whole is practically identical in habit with a pinna of the Palæozoic species *Pecopteris arborescens.* The longest pinna is 4·5 cm. long, but when complete it must have considerably exceeded this. It is worth noting that the pinnules are inclined to the axis of the pinnæ like the arms of a wide open V (Fig. 2*a*), as in the Wealden fern *Weichselia Mantelli.*[1] It is impossible to make out the venation characters, but here and there one sees traces of a midrib and of lateral veins; in one place I noticed what appears to be a lateral connection (Fig. 2) between two of the secondary veins.

While admitting that it is futile to attempt to determine the precise nature of the fossil with any degree of certainty, I am inclined to favour the comparison with the Wealden *Weichselia* as the most likely guess at affinity.



3 a



3

Specimen III. Fig. 3. (No. 1423.) From Wadi Araba; about 300 miles north of Edfu, near the shores of the Red Sea.

The specimen consists of a few fragments of pinnæ bearing closely-set pinnules as shown in Fig. 3; the venation is more clearly seen in the enlarged drawing, Fig. 3*a*. Accurate identification is almost hopeless; it is, however, permissible to suggest that the appearance of the pinnules reminds one of a Mesozoic rather than of a Palæozoic species. Such a fern as *Klukia exilis* of Jurassic age presents a close resemblance in the form of the pinnæ to the Egyptian specimen.

Geological Age of the Rocks from which the Specimens were obtained.

Specimen I. *Clathropteris egyptiaca*, sp. nov. Such evidence as the fragment affords is primarily in favour of a Rhætic or Lower Jurassic age.

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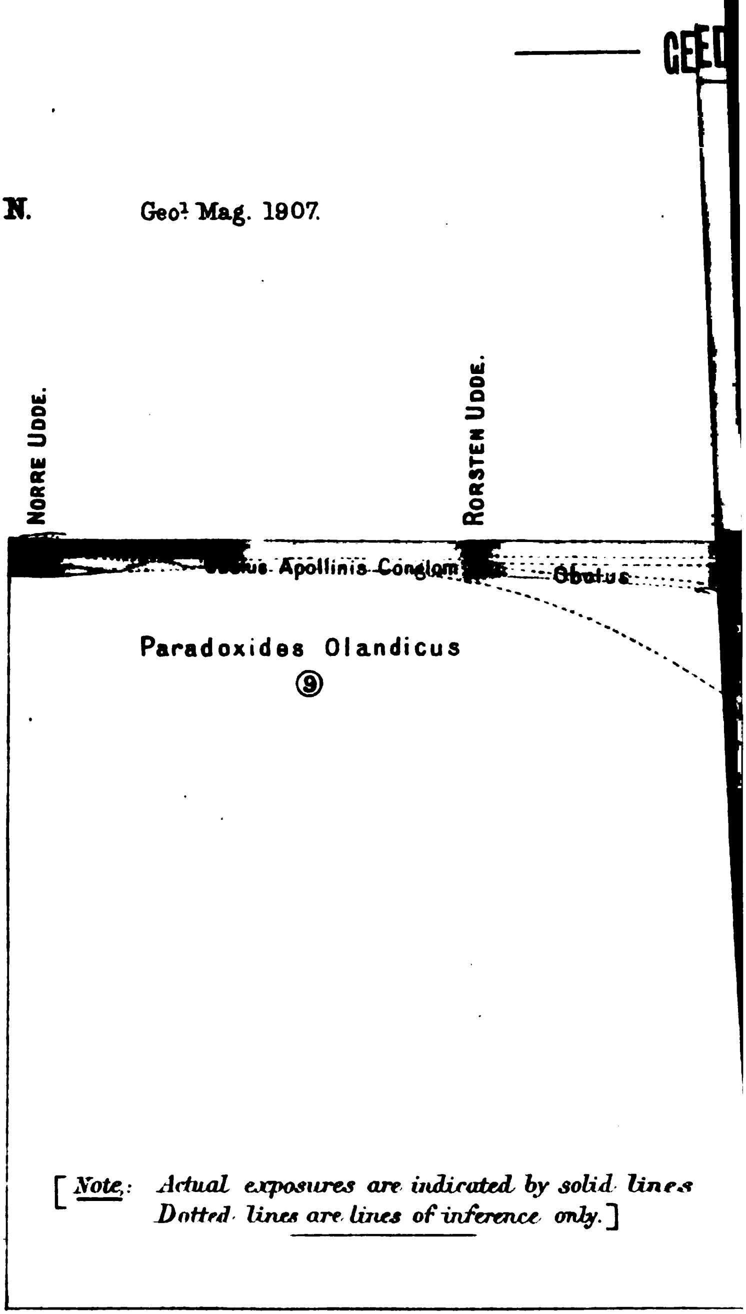
[1] Seward: The Wealden Flora, pt. i (Brit. Mus. Catalogue, 1894). See also Nathorst: Arch. Ver. Freund. Nat. Meckl., Jahr. 44, 1890.

Geol. Mag. 1907.



[*Note*: *Actual exposures are indicated by solid lines. Dotted lines are lines of inference only.*]

VERTICAL SCALE – $\frac{1}{200}$.

Specimen II. Although the state of the specimen is not such as to stify the use of a name, it is possible that it represents a fragment of *eichselia*, and if so, the age may be put down as Wealden. This mparison is made with considerable hesitation, and it is not one to hich any weight should be attached.

Specimen III. *Cladophlebis* sp. It is convenient to adopt this neric name as a designation for the pieces of pinnæ bearing nnules of the *Cladophlebis* type.

The resemblance to *Klukia exilis*, while suggestive of a Jurassic rizon, is of practically no value, as this form of pinna is one of the mmonest among ferns of different ages.

I.—THE LOWER ORDOVICIAN ROCKS OF SCANDINAVIA, WITH A COMPARISON OF BRITISH AND SCANDINAVIAN TREMADOC AND ARENIG ROCKS.

By William G. Fearnsides, M.A., F.G.S.,
Fellow of Sidney Sussex College, Cambridge.

ITH A COLOURED FOLDING-SECTION, PLATE VIII; AND PLATE IX.)

Introduction.

S a worker among the Lower Palæozoic rocks of Wales I have for some years devoted a good deal of time to the study of nadoc and Arenig rocks, and in common with others have therefore n wished to check the results attained in that district of great nesses and tectonic complication by reference to the thinner and e fossiliferous series of the undisturbed areas of Northern Europe. n, therefore, the Senate of the University of Cambridge granted the Worts Fund for travelling scholars, and instructed me to y the interrelationships of the Tremadoc and Arenig Series in dinavia, I at once took advantage of the opportunity, and spent onths of May, June, and July in hammering over those rocks in eld.

e course of my journey took me through Skåne, Öland, Dalarne, Gefle and Upsala district, Östergötland, Vestergötland, and the iania and Eker districts of Norway in order, and with the tion of Nerike I was able to visit almost all sections where ower Arenig has been seen to rest upon Tremadoc rocks. The ns visited have all been described or mentioned in various local irs by Swedish or Norwegian geologists, but I have not been o find any detailed English account of them, and as also I have et with any comparative account of the variation of the various ers of the succession in the different districts, I have thought systematic stratigraphical account of the rocks as taken from n field observations may be of interest.

present communication, therefore, though based entirely upon n field notes, makes no pretence of recording new facts, and is riginal in so far as it is comparative, and that its comparisons o bring out certain new evidence as to the physical conditions Tremadoc and Arenig time. Except in the matter of the time ons shown by Dictyonema which is here put forward and discussed for the first time, I have passed over all questions of palæontology and constitution of the various sub-faunas with a brief reference to the work of the Scandinavian geologists, and have quoted only such fossils as actually fell to my hammer.

In searching out the exposures discussed I have made full use of the maps and memoirs of the Swedish Geological Survey, and in addition have enjoyed the advice of and conversation with such eminent geologists as Professors Törnquist, Brögger, Möberg, and Docents Wiman and Kjaer, to whom, as well as to other authors of maps and papers, I would tender my warmest thanks. In the course of my travels and in the working up of my field notes I have found the following papers most useful, and those who wish to pursue the subject further may be referred to them. I have arranged the references geographically in the order of the districts visited, and in the body of the paper shall refer to them by the letters and numbers appended.

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Subsequent workers will also find the recently published papers by Wiman on the Dalarne *Ceratopyge* beds (C), G.F.F., 1906, and Von Post on the similar beds of Falbygden useful, while the masterly new monograph of the "*Ceratopyge* region" by Moberg & Segerberg, Med från Lunds Geol. Faltklubb, ser. B, No. 2, 1906, like the older monograph of the graptolites of the Phyllo-Tetragraptus Skiffer by Törnquist, Lunds Univ. Arskrift (G), 1901 and 1904, is quite indispensable to all students of "Lower Silurian" palæontology. The "*Ceratopyge* region" monograph contains also a full authors' bibliography of the palæontology of the Scandinavian and some equivalent British and foreign beds here discussed, and this it is therefore unnecessary here to reproduce.[1]

Note.—The following portion of the paper in its present form was read before the Geological Society on Feb. 27th, 1907, and is published in abstract in the Proceedings of the Geological Society of March 4th, 1907.

In stating briefly the results of my work I shall consider the Tremadoc and Arenig rocks of Scandinavia in the three broad divisions—

C. *Didymograptus* shales and Orthocerakalk,
B. Glauconite shales and Ceratopygekalk,
A. *Dictyonema* and *Bryograptus* shales,

taking them in the order of their superposition. Along with division A I shall discuss also the underlying highest zone of Alum Shales (the *Acerocare* zone), into which in all parts of Scandinavia it passes continuously.

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[1] See also note on this monograph in Geological Magazine, February, 1907, by W. G. Fearnsides, p. 85.

A. *The Dictyonema and Bryograptus Shales.*

Taking first the areas where sedimentation was completely continuous throughout the period A, we may begin with the Kristiania district. Here the oldest beds in which we are interested are the upper beds of Professor Brögger's 2*d* (K 1), which both palæontologically and lithologically belong to the *Olenus* or Alum Shale Series. They contain *Parabolina heres* and *Cyclognathus micropygus*, and with them certain fragments of Asaphid trilobites, but as the Krekling section which I visited was only attainable by digging I can say little else about them. Above these come the 30 feet of shales 2*e* with *Dictyonema* and *Bryograptus*, but without trilobites, and these seem to me capable of further subdivision. Unfortunately I have no detailed knowledge of the difficult group of branching graptolites, but in the magnificent stream sections on the western side of the valley a little south of Krekling station one could easily recognize time mutations in the general aspect of the *Dictyonema* in the different beds. The earliest of them are usually ill preserved, and I could obtain no specimens showing the proximal end. In adult stipes the cells are very indistinct, and rarely project more than about a quarter of the diameter of the common canal. The connecting-rods seem to take the place of cells, and though thin are very numerous. The stipes are usually close together and very nearly parallel, they branch at all sorts of levels, and the resulting mesh has the form of somewhat elongated rectangles or parallelograms. Upwards this ancestral type of *Dictyonema* seems to diverge into two distinct families, the one approaching the true graptolites (*Dictyograptus*), while the other seems more nearly related to the Dendroids (*Dictyonema, sensu stricto*). Of these the former soon develops well-marked cells, which, though a trifle irregular, tend to become uniserial, and so come into agreement with the early graptolites, while in the latter a crinkly longitudinal ornament appears upon the polypary, and the cells though well formed are small and are developed spirally at angles of about 120°. With this divergence in the cell characters of the adult, we are able to trace an even more notable change in the character of the proximal end, for whereas the *Dictyograptus* forms develop like a fisherman's net from a sicula of no great length with primary branches diverging at an angle rarely greater than 90°, the Dictyonemas grow basket-like from a long narrow tube or nema, and diverge at angles which in the later forms approach 160°. The character of the crossbars also alters, for while in *Dictyograptus* their development is ever more and more delayed until they become practically abortive, in *Dictyonema* their importance increases, and the general aspect of the later forms is that of a square or rhomboid mesh in which crossbars and stipes are of approximately equal importance. Branching in both families appears to tend to dichotomy at regular intervals, and hence the later Dictyonemas and Dictyograptids are very flabelliform. So far as one can judge the specimens figured by Brögger as *Dictyograptus flabelliformis* come a little more than half-way up the series at Krekling. They tend rather to the *Dictyograptus* than to the *Dictyonema* family, and as shown in the original figure exhibit well-marked cells on the outer stipes of the net. The mutation *D. norvegicus*, on the other hand, seems to be a comparatively late form, and shows nearly all the features of a well-marked Dendroid. At a horizon very near the place of *Dictyograptus flabelliformis* true graptolites without crossbars appear among the Dictyonemas, and as we pass up form an ever-increasing proportion of the graptolitic content of the shales. Curiously enough, these true graptolites, which may for the present be alluded to as *Bryograptus*, though intimately interlaminated with *Dictyonema* or *Dictyograptus*, are hardly ever seen upon the same bedding plane, and it would almost seem as if they flourished under slightly different conditions. *Dictyonema* and *Dictyograptus*, though gregarious, are also to some extent exclusive towards each other.

Above the *Dictyonema* beds are the calcareous shales and limestones with *Symphysurus incipiens*, 3*a* α, which, though grouped by Brögger with the Ceratopygekalk, would be included in the A beds in Sweden. They mark a vast change in the character of the sedimentation, and hence the fact that Asaphids are quite as abundant as the Olenids is not surprising. The overlying Ceratopygeskiffer 3*a* β, which shows a temporary return towards Alum Shale conditions, contains a *Ceratopyge* fauna, but the finding at Gjeitungholmen of a slab from this division showing *Dictyonema* and *Bryograptus* on the one side and *Shumardia* on the other convinces me that it is really a passage series between A and B.

In Skåne the *Dictyograptus* beds like the *Acerocare* zone below are lithologically again a part of the Alum Shales. At Sandby (near Lund) in the western district the *Acerocare* zone is subdivided by the Swedish geologists (S 1 and S 6) into (*c*) bed with *Parabolina heres*, (*b*) bed with *Parabolina megalops*, (*a*) bed with *Parabolina acanthura* and *A. ecorne*, while at Akarpsmölla an additional higher subzone (*d*) with *Acerocare* = *Cyclognathus micropyge* is also distinguished. In the bed (*b*) I was able to obtain a few fragments of Megalaspid tails, and in certain fine-grained orstens[1] of (*c*) such occurrence is not rare. Above this *Acerocare* zone come the shales and pyritous orstens with *Dictyonema*, not over well preserved, but quite like the *Dictyonema* of the lowest 2*e* of Kristiania. This bed has the further interest that it has yielded to Moberg (S 3) *Lingula*, *Acrotreta*, Megalaspid fragments, and a trilobite *Hysterolenus Törnquisti*, "which is intermediate between *Ceratopyge* and *Dikellocephalus* on the one hand and *Niobe* and *Megalaspis* on the other." At Fågelsångsbeck (S 2), a mile nearer Lund, the section is continued, with what omission I cannot tell. There the lowest bed seen is a black Alum shale with well-preserved *Clonograptus flexilis*, etc., and fine large *Obolella Salteri*. Some seven feet above this certain much weathered shales show laminæ crowded with coarse, square-meshed, strongly-barred *Dictyonema* like *D. norvegica* (and as such identified by Moberg), alternating with ill-preserved Bryograptids. Large orstens associated with these shales appear to be unfossiliferous. Half a mile further up the same stream, however, greyer shales containing a multitude of crushed Bryograptids (*B. Kjerulfi*) alternate with thin bands of impure limestone containing *Shumardia*, and are seen to underlie the Ceratopygekalk (C).

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[1] The name 'orsten' is applied by the Swedes to the highly crystalline bitumen-bearing concretions which occur among the Alum Shales. These are the Stinkstein or Stinkkalk of the Germans. They have been formed not long subsequently to the time of the deposition of the shales, and often contain many beautifully preserved fossils.

In Eastern Skåne (S 10) the *Dictyonema* beds are better exposed, and at Flagabro the gradual mutation of the *Dictyonema* type along the lines suggested at Krekling can be followed in all details. The usual *Dictyonema* in Swedish collections seems to come from Flagabro and are of the true *Dictyograptus flabelliformis* type. At Gislofshammar, south of Simrishamn, the section is mostly under the sea, but the beach material thrown up provides beautiful late Dictyonemas of a basket-work type interbedded with *Clonograptus*, in addition to all the types seen at Flagabro. At Jerrestadt I was able to find the bed with *Clonograptus flexilis*, also that with *Dictyonema norvegica*, but was most interested in finding an orsten within the *Acerocare* zone which was full of *Niobe* and, I think, *Symphysurus* also. At Andrarum (S 9) the main section stops at the *Parabolina heres* zone, but in the stream bed below the Pannhusset I had the good fortune to find a fine orsten containing an early type of *Dictyonema* together with *Hysterolenus*.

In Öland the *Dictyonema* and *Bryograptus* shale succession is much reduced, and complete only in the extreme south (O 2 and O 4). The *Acerocare* zone at the top of the Alum Shales is nowhere separated, but exposures are poor at this horizon, and there is no reason to suppose that it is absent. *Dictyonema* shales to a thickness of 7 feet are recognized along an outcrop of about 20 miles in the south of the island. The only *Dictyonema* I could find are of the *D. flabelliformis* type, but the upper beds with abundant *Obolella Salteri* contain broken stipes of true graptolites, which are probably *Clonograptus*, and pass up to about 6 feet of similar shales containing brachiopods and trilobites which continue on into the Ceratopygekalk above. North of Borgholm (O 5) *Dictyonema* occurs in certain orsten pebbles and in the soft shales which form the matrix of a curious phosphatic conglomerate which is found there. This conglomerate is very inconstant and always quite thin; it rests upon and among sundry *remanié* orsten concretions of the various zones of *Olenus* shales, and the shaly beds of its matrix pass gradually up into 3 or 4 feet of quite ordinary Alum Shales with orstens. These in their lower part contain *Obolus Salteri* and horny brachiopods, while in the upper is the *Orthis Christiani* so common in the Ceratopygekalk. Further to the north *Dictyonema* and *Obolus* shales together thin to less than 20 inches. Cherty bands with thick-walled *Obolus* then come in, and the whole passes to a nodular sandy mass quite like the *Obolus Apollinis* conglomerate of Dalarne (D 1) and Western Russia. In this the most northern district of Öland the basal *Dictyonema* shales or conglomerate transgresses still further, and rests upon the denuded but unweathered edges of the lower *Olenus* shales and the *Paradoxides* shales and sandstone (O 6).

In Vester and Öster Götland the A beds are again incomplete, but the law of the presence or absence of the various members remains to be discovered. I find no record of the occurrence of the *Acerocare* zone within these provinces, but a thin bed of rather barren shale just below the *Dictyonema* zone may well represent it. The *Dictyonema* zone itself also is rarely seen, but its absence is probably due rather to subsequent erosion than to failure of deposition. In Vestergötland *Dictyonema* shale is recorded by Linnarsson (W 1) at certain places around Halleberg and Hunneberg, but most unfortunately I was not able there to find it. At Kelfva, west of Mösseberg (W 4), and at Orreholmen, near Gerumsberg (W 5), in the Falbygden district, however, its lower members are preserved beneath the Ceratopygekalk. At Kleva the highest beds seen contain the largest and widest meshed *Dictyograptus* I have ever seen. An orsten among the shales containing this is described by Von Post[1] as including a bedding plane with abundant glauconite, but this I did not notice.

In the Berg or Vreta Kloster district of Östergötland (E 1) there are several fine exposures, and at Storberg not less than 13 feet of *Dictyonema*-bearing shales are seen. Here the *Acerocare* beds seem to be actually missing, and a bed of calcareous or cherty sandstone with fragments of thick-walled *Obolus* and up to a foot in thickness separates the *Dictyonema* beds from *Peltura*-bearing orstens.[2] The *Dictyonema* beds seem fairly complete, and the highest beds contain stipes of true graptolites along with *Dictyonema.* These beds are worked along with the underlying *Olenus* shales, and contain sufficient bitumen to be quite useful for fuel.

In Nerike the *Dictyonema* beds, shales, and associated sandstones appear to be absent.

From the drift of Gefle and Upsala, Wiman (B 1) has obtained many blocks of *Obolus*-bearing sandstone comparable with the *Obolus* conglomerate of Öland. Here, however, it is truly conglomeratic, contains much glauconite and some phosphate nodules, and has a limestone matrix. With it are associated boulders of certain shales containing stipes of graptolites, *Shumardia*, and also *Hysterolenus Törnquisti* (B 2).

In the Lake Siljan district of Dalarne the *Obolus* sandstone described by Törnquist (D 1) from Vicarby and Klitterberget may probably be referred here. It is now well seen in the railway cutting half-way between Rettvig and Vicarby. There it has a thickness of from 3–7 feet, and consists of fresh chips of quartz felspar and mica with angular granite pebbles and a kaolin matrix. Its cement is calcareous, and it rests upon an irregular surface of granite, which shows contemporaneous weathering, affecting different grades of rock so differently that the depth of weathered rock varies from two inches where the rock is aplitic to as many yards in the coarse-grained granite. Of fossils *Obolus Apollinis* occurs in great multitudes, but other species are indeterminate.

A Subaqueous Unconformity.—At the close of the *Dictyonema* shale period sedimentation over the eastern portion of Scandinavia must have become discontinuous, and in certain places may at times have been replaced by erosion. Of actual uplift with its attendant following of overlap and unconformity there is little evidence, but a close inspection of the phenomena presented by the beds B, Glauconite shale and Ceratopygekalk, will convince the most sceptical that none of the happenings which we generally associate with spasmodic subaqueous erosion are missing. We have noted that the upper *Dictyonema* series is complete only about Kristiania and in Skåne, and that passing thence north-eastward its thickness decreases often to zero, the highest beds being the first to go. Further, we have seen that though in North Öland and Östergötland some part of the series reappears, it is always associated with a sandy or conglomeratic phosphate bed containing fragments of all manner of older Cambrian and even Pre-Cambrian rocks, and shows therefore a passage towards the *Obolus* conglomerate facies of Dalarne and Western Russia. The manner of this change is well brought out by the section through the Cambrian and *Ceratopyge* rocks of Öland (Plate VIII) which I have plotted partly from the records contained in the new Swedish Geological Survey Memoirs of the Island of Öland (O 1–6), and partly from my own observations. This section, though fairly true to scale, has a vertical scale about 1250 times the horizontal, and it will therefore be readily understood that in the field all dips are imperceptible, and that quite the most remarkable feature of the unconformity is the thinness and extraordinary regularity of the beds affected. Most unfortunately the south end of the island of Öland just fails to contain an area of continuous deposition, but from the fact that at Ottenby, as shown by Moberg (O 4), shales above and below the surface of discontinuity contain identically the same fauna, it must follow that the time value of the discontinuity must there be reduced almost to zero.

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[1] G.F.F.S., November, 1906.

[2] Wiman (E 2) at Vestanå describes a similar sandstone bed 2·08 m. in thickness interlaminated with *Dictyonema*-bearing shales.

B. *The Glauconite Shales and Ceratopygekalk.*

Returning now to areas of continuous deposition, we notice first the *Ceratopyge* shale (Brögger's 3*a* β) about Kristiania. This, as already mentioned, is in its lower part an Alum shale with orstens, but upwards becomes greyer and more calcareous. Its thickness is some 16 to 20 feet. Its lowest beds with their brachiopods, *Bryograptus* and *Parabolina* have been already considered with the *Dictyonema* and *Bryograptus* shales. Its middle beds also yield *Bryograptus*, but with it abundant *Shumardia*, *Agnostus Siedenbladhi*, *Euloma*, and *Ceratopyge*, while the higher nodular shales and limestones rich in *Triarthrus Angelini* seem otherwise quite indistinguishable from the overlying Ceratopygekalk. The Ceratopygekalk 3*a* γ consists (K 2) of five or six beds of a blue-grey nodular limestone, together about 4 or 5 feet thick. It is now rather difficult to work, but I was able to prove for myself the existence of *Niobe*, *Symphysurus*, and *Megalaspis* in some beds, and of *Ceratopyge*, *Euloma*, and *Shumardia* in others. The late Tremadoc genera (British), such as *Cheirurus*, *Dikellocephalus*, and *Holometopus* (*Ampyx*), are also recorded from this horizon, though not mentioned in the zone 3*a* β below. As compared with other Scandinavian Ceratopygekalk, 3*a* γ of Kristiania is remarkable for its small content of glauconite, which here occurs only in streaks and lines with the shale partings between the nodules of the very highest beds. The "Korrosionsgruppar,"[1] or Erosion-pocketing, to be described later, also is not much in evidence. *3a* γ gives place upward rather abruptly to the nodular grey shales of the Phyllograptus shale *3b*.

In Skåne Ceratopygekalk is very indifferently exposed, and is now known with certainty only at the mill dam close to Fågelsång (S 2 and C). There separated from baked *Phyllograptus*-bearing shales by a little sill of rotten diabase, some three or four beds of decayed and very ferruginous but once crystalline limestone alternating with shales containing sheared *Bryograptus*. Both limestone and shales contain *Ceratopyge* and *Shumardia*, and pass down into the *Bryograptus Kjerulfi* shales mentioned as containing the *Dictyonema norvegica* above. A similar limestone mentioned by Linnarsson & Holst (S 10) as occurring at Jerrestadt mill in East Skåne is no longer visible.

In all other Swedish districts the failure of the sediment supply has left the *Ceratopyge* beds more or less incomplete, and only in South Öland do we find any further certain representatives of Brögger's *3a* β of Kristiania. It is possible that similar beds were really deposited over the greater part of Öland and Vestergötland and Östergötland, but if so must have been caught up again almost immediately, and the succeeding glauconitic division can be seen to rest variously upon *Ceratopyge* shale and *Dictyonema* shale, and upon the *Acerocare*, the *Peltura*, the *Sphærophthalmus*, and the *Orthis lenticularis* zones of the Alum Shale. In these districts glauconitic shales and Ceratopygekalk together are never more than 6 or 7 feet thick, yet have a distribution which is almost universal. Despite their thinness, their variations in lithological character are multitudinous and so complex in their details that they defy further classification. As a whole the beds are characterized by the presence of a large proportion of glauconite grains and by the strange method of bedding which has been termed "Korrosionsgruppar,"[2] or Erosion-pocketing (see Plate IX). The matrix of the glauconite varies from shale quite comparable with the Alum Shales to a limestone of the purest whiteness, and the glauconite though sometimes absent may be present in any proportion. As a rule the lower beds are more muddy and the upper more calcareous, but either upper or lower groups may be entirely absent. Whenever the glauconite is very abundant it is usually associated with knobs or nodules of brown phosphate ranging up from the size of a pea to the size of a walnut, whose unworn surface contrasts strongly with the lustrous black or green of the grains of glauconite. Pyrites in well-formed cubes or pentagonal dodecahedra in single crystals or in shapeless lumps is also rather a feature of the bed. With the phosphate nodules, especially at the base of the series, are clay galls of older beds and angular fragments of phosphatized orsten, which in some cases retain recognizable fossils. In places where the glauconite comes to rest upon a discontinuous orsten bed the shales between the individual orstens have usually been scoured away, and the interspaces filled up with angular fragments of that or any other

[1] J. G. Anderson, "Über cambrische und silurische phosphorit-führende Gesteine aus Schweden": Bull. Geol. Inst. Upsala, vol. ii (1895).

[2] J. G. Anderson: Bull. Geol. Inst. Upsala, 1895.

orsten bed with a matrix of glauconitic shale or limestone containing a *Ceratopyge* fauna. Such a phenomenon is very well seen at Nya Dala and Ekedalen in Southern Falbygden (W 5), at Mosseboo under Hunneberg (W 6), and at Borgholm in Central Öland (O 5). At Dala a pair of fine flat orstens some 7 feet in diameter and crowded with *Peltura scarabæoides* were seen to overlie some 3–7 inches of glauconitic shale with *Orthis Christiani* for a length of about 6 feet. At Mosseboo the upper surface of a calcareous bed with *Sphærophthalmus* is so brecciated and the basal Ceratopygekalk so dark and shaly that the line of junction is difficult to find in even the cleanest of hand-specimens. Such difficulty, however, is most unusual, and the base of the Glauconiteskiffer, however irregular, is almost always clean-cut, and the topmost Alum Shales so little weathered that either in soft shale or hard orsten the Alum Shale fossils are preserved and recognizable within a twentieth of an inch of the boundary. All these characteristics of the Glauconite shale and Ceratopygekalk it shares with most Greensand deposits, and especially with such formations as the Cambridge Greensand, which follows a period of subaqueous erosion. The phenomenon of Erosion-pocketing or Korrosionsgruppar is more peculiar, and, so far as I can learn, almost unique among known sedimentary rocks. It is undoubtedly an erosion phenomenon, and as such is difficult to describe. It has been already discussed by Anderson in his well-known monograph of the Phosphate deposits of Sweden,[1] but no English notice of it seems to have appeared, and no satisfactory explanation of its mode of formation is forthcoming.

The most striking museum specimens of Korrosionsgruppar are obtained from the base of the Glauconiteskiffer, where the rock is sufficiently calcareous to hold together, and rests upon a bed of orsten or Alum Shales also firm enough not to be friable. Such a specimen from Ulunda in Falbygden is depicted on Plate IX in Figs. 1 and 2, which show photographs of two sides of the same block taken at right angles. The figures are photographed natural size. The lower part of the block is a homogeneous, fine-grained, and somewhat earthy orsten of the *Peltura* zone, and, as is well shown by the photograph of the under-surface, Fig. 3, and by the projecting lines of trilobite fragments seen in Figs. 1 and 2, retains its bedding quite undisturbed. The junction with the glauconitic Ceratopygekalk is absolutely sharp, but quite irregular, and it may be seen that the irregularities are produced by a process of pitting rather than of grooving or moulding. The pits are generally round or oval and rather pocket-shaped, but never more than an inch or two deep, and though their mouths may vary from the size of a lead pencil to that of a five shilling piece, the diameter near the bottom is rarely bigger than a sixpence. The sides of the pits may be vertical, sometimes slightly overhanging, but they are more often inclined one towards the other downwards, and the depth is by no means proportional to the diameter of the opening. The bottom of the holes is usually somewhat rounded, and is often almost hemispherical. In general the lip of the pit is rounded, but in some cases sides of adjoining pits meet in a cusp whose solid angle may be only some 30°, but in such cases I think that the pits must be of different

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[1] Bull. Geol. Inst. Upsala, 1895.

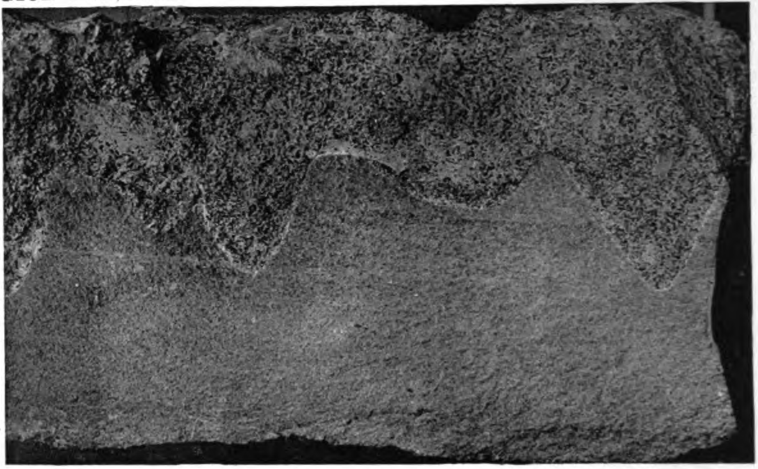
Glauconitic Limestone with Orthis Christiani.
Boundary
Orsten with Peltura scarabeoides.

FIG. 1.

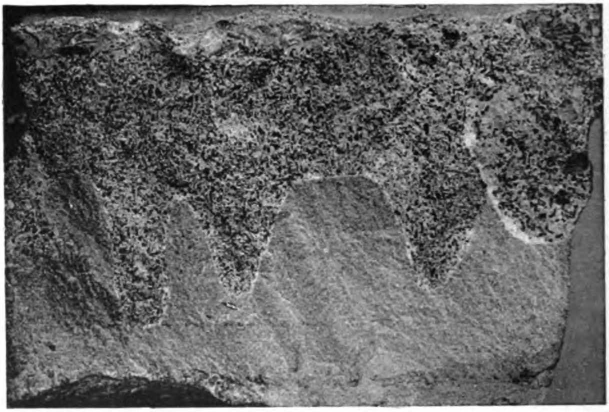

FIG. 2.

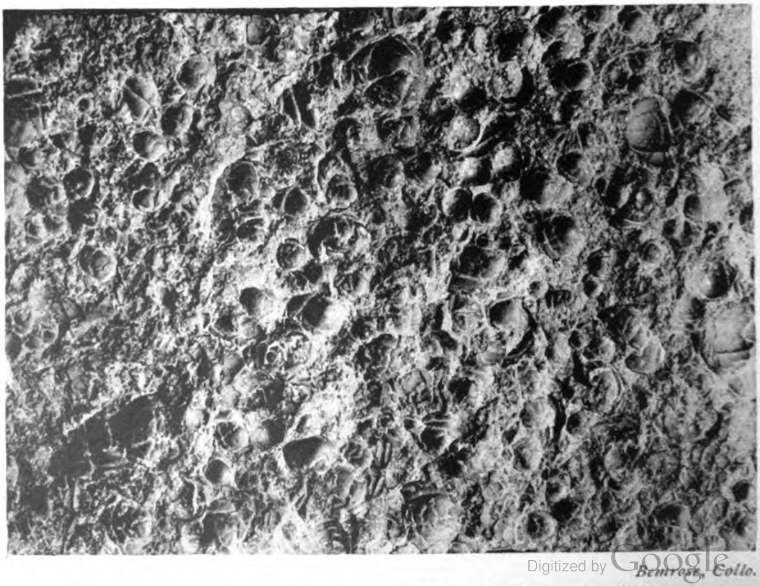
Under surface of block shewing undisturbed Peltura scarabeoides.

FIG. 3.

Bemrose, Collo.

EROSION POCKETS OR "KORROSIONSGRUBBAR," ULUNDA STENBROT ages, and that the first one being buried in sediment the superposition of the second over a part of the site of the first must be accidental. As now observed the neighbouring pits occur so close together that over a district which, despite the ravages of denudation, still measures some 500 miles from north to south and 250 from east to west, it is rare to find a horizontal distance of more than a few inches without its pit. That at any instance during their formation the pits were so close as this is not, however, clear, and, when one considers the vast thicknesses of correspondingly coarse material which were accumulated during the period of the Glauconiteskiffer and Ceratopygekalk, is not probable. The infilling matter of the pits is almost always glauconite-bearing, and whether the matrix be soft shale or hard limestone it is noticeable that larger glauconite grains and rolled fossil fragments line the bottom, while smaller glauconite grains and matrix fill up the rest of the hollow. In this description I have hitherto only mentioned the Erosion pockets or Korrosionsgruppar, which occur at the surface of separation between the glauconite group and Alum Shales below. There the phenomenon is undoubtedly most easy to follow, but throughout the Glauconite shale and Ceratopygekalk each and every bedding plane which carries glauconites shows also Erosion pockets. The *Orthoceras* limestone also, where glauconitic, continues the same phenomenon on a more limited scale, and even where not glauconitic certain of its beds show a Korrosionsgruppar (or pocket erosion) arrangement of the coarser fragments in holes bored into more homogeneous material. Within the Ceratopygekalk bedding planes with Korrosionsgruppar occur so abundantly and near together that the successive laminæ interlock very intimately, and a considerable thickness of this slowly formed rock is rendered quite thick-bedded and massive in appearance. A freshly broken block from such a rock has the aspect of a photograph of a gravel-pit where the gravel, once calcareous, has suffered loss by solution, and has sagged down into the pipes so common under those circumstances.

EXPLANATION OF PLATES.[1]

Plate VIII.—Generalized section along the west coast of the Island of Öland, showing the actual succession and mutual relationships of the various subdivisions of the Cambrian and Tremadoc rocks there exposed. Actual observation points are indicated by solid lines.

Plate IX.—Erosion pockets or 'Korrosionsgruppar' at the base of the Tremadoc Series of Vestergötland.

Fig. 1. Northern face of a block showing the irregular boundary between calcareous glauconitic shale with *Orthis Christiani*, *Euloma*, *Niobe*, etc., and an even-bedded orsten of the *Peltura scarabæoides* zone.

Fig. 2. Western face of the same block showing similar phenomena. Note here the sharp cusp at the northern (right-hand) end of boundary-line due to the intersection of erosion pockets of different ages.

Fig. 3. Under-surface of same block showing good heads, etc., of *Peltura scarabæoides* undisturbed by the processes of erosion which have produced the adjoining Korrosionsgruppar.

The block, three surfaces of which are here depicted natural size, was collected at Ulunda Stenbrot, about one mile east of the church of Varnhems Kloster, Vestergötland.

[1] Plate X will appear with the conclusion of this paper in the July Number.

(*To be concluded in our next number.*)

IV.—NORTH NORFOLK GEOLOGY: THE CHALK AND ITS DISLOCATION.

By Sir HENRY H. HOWORTH, K.C.I.E., F.R.S., F.G.S.

IN venturing to offer some further criticisms on the interpretation of the phenomena presented by Norfolk geology published in the memoirs of the Geological Survey and elsewhere, I may state that these criticisms are the result of several visits to the county in which I have either drawn or made detailed notes of nearly every critical section along the coast.

Another visit, in which I have recently traversed many miles of country and revisited many important sections, has greatly strengthened the views already published by me in previous papers, and has made me more than ever dubious of the greater part of the *theoretical* explanations of the local phenomena contained in these memoirs.

I have said before, and I wish now to repeat, that the frailty of much of this official work has been largely due to the fact that in East Anglia and Essex the Geological Surveyors have been so badly equipped financially by the Treasury for the work they have been expected to do, and which cannot be done efficiently until a great deal of experimental boring and other expensive modes of testing the surface beds away from the coast, below as well as on the surface, have been carried out, for which funds have not been available. To map the superficial facies of a vast area like Norfolk with no other guides to the surface beds than casual exposures in marl-pits or gravel-pits, most of which are mere shallow scrapings of the skin of the soft strata, is utterly futile, except as a tentative proceeding, and it is misleading beyond measure when, with no better guides to the distribution of these beds and of their possibly disturbed or undisturbed conditions than can be got from such accidental and adventitious exposures, far-reaching theories and explanations are published under official sanction.

This only accounts, however, for a part of the mischief. I cannot help regretting that both in regard to the accessible facts and in regard to the discussion of the theoretical inferences the memoirs in question are so inadequate. It ought not assuredly to have been left to a foreign geologist to first explain the succession of the English Chalk, including that of Norfolk, nor to two amateurs with only casual opportunities to first give a detailed and masterly zonal classification of the same beds, nor to Mr. Brydone to first give us the necessary materials for adequately discussing the problem of the Chalk bluffs at Trimingham.

Again, it is very unfortunate that in regard to the boulders of the Norfolk drift so little material should be given us in the Survey Memoirs for discriminating the original sources of the stones, the distribution and relative proportions of the different varieties in different districts, and especially the sorting out of the rolled and the unrolled boulders. It is also a pity that in analyzing problems like those connected with the drifts of Norfolk a more systematic effort should not have been made to ascertain rather more carefully from the very intelligent fishermen the nature and constituents of the adjacent sea-bottom, and that on the other hand in dealing with the question of the origin of the local beds so much reliance should have been placed upon the foreign stones in the shingles on the shore instead of those in the deposits inland, for I am more than ever convinced that a great proportion of the foreigners in the shingles, especially the so-called Scandinavian boulders, are derived from ballast, either from wrecks or discarded from ships, and are entirely misleading in their testimony.

In regard to the *theories* which abound in the memoirs of the Geological Survey dealing with North Norfolk, and which have proved a snare to many credulous people, I hold that they are for the most part quite out of place there. Theories, especially highly polemical theories, ought to find a place in the private publications of the Geological surveyors and not in Government publications where we want facts. We can draw our own inferences.

Can anything, in fact, be more disconcerting than to find the President of the Geological Section at last year's meeting of the British Association (himself a prominent member of the staff of the Geological Survey) completely discarding the theory of interglacial periods which forms the keynote of the explanations of the Norfolk drifts in the memoirs of his own colleagues, Mr. Horace Woodward and Mr. Clement Reid, and which is adduced quite confidently as well-established in their descriptions of these beds. It is perfectly plain that if Mr. Lamplugh's address contains sound reasoning on this subject the theoretical explanation of the surface geology of East Anglia contained in the Survey Memoirs ought to be revised as soon as possible, for these theoretical conclusions are no longer tenable.

That Mr. Lamplugh is right in his views about interglacial beds I have no doubt. The only complaint I have to make is that it should be so belated. The conclusions which he now publishes as if he was the first to generalize in their sense have been pressed for thirty years in many papers and two big works by one Howorth. None of these publications are noticed in his address, which contains, by the way, a good many references to obscure foreign memoirs on the subject, which took me much time to find, and which appear in it as if they had not been previously discovered by other people. It is more to the point, however, that Mr. Lamplugh should have been constrained by the force of the evidence to discard his colleagues' views on interglacial beds so completely, and notably those of Mr. James Geikie, the author of the Glacialists' Bible.

Let us, however, proceed. I have said that until the boring rod has been used in many parts of Norfolk and Suffolk we shall never know what the true history of the later geological changes in these counties has been. The only part of the work for which adequate material is in fact available, until a great deal of such *experimental* digging has been done, is the mapping of the coast sections, which do afford exceptionally rich materials where the evidence is not hidden or distorted by the occurrence of long stretches of fallen débris forming a sloping talus. This talus, however, on a coast where the sea is very active is periodically cleared away, and fresh clean surfaces are therefore being daily exposed, so that every part of the coast may at one time or other be critically analyzed and mapped.

The heartbreaking result of this renewal of the cliff sections, however, as Mr. Horace Woodward and others have frequently deplored, is that the constitution and the physical arrangement of the greater part of the beds in question differs so completely at different times and almost in every yard of these very famous cliffs that no section, however carefully drawn, is of more than ephemeral interest. This year's section will inevitably be of no use to us as a picture of what the kaleidoscopic beds will be like when a fresh collapse has taken place and two or three yards have been shaven off the front of the cliff. This baffling inconstancy is a continual source of complaint among all students of Norfolk geology.

It is, therefore, quite futile to generalize from any particular section without taking into account its purely transient, temporary, and local character. The kaleidoscopic feature here referred to does not apply to the whole of the sections, of course, but only to their loose materials, to the clays, loams, gravels, and sands, which everywhere overlie the more stable deposits.

I would first speak about these latter beds. From East Runton to the great shingle beds at Weybourne, where the cliffs abruptly end, the chalk, where exposed in or at the foot of the cliffs, is immediately covered by a remarkable bed, quite unmistakable, and occurring quite continuously, except in certain very limited lengths of the coast where it has been forcibly denuded. This bed does not seem to me to have been adequately described by Mr. Clement Reid. He says of it: "At Weybourne, and wherever the surface of the chalk can be examined, there is nearly always a bed of large unworn or little worn flints at the base of the Crag. This is the 'stone bed' of Norfolk geologists, but it does not necessarily belong to any one horizon; exactly similar beds of unworn flints are now being formed from above high-water mark to about 10 fathoms, and are caused merely by the wearing away of the soft chalk. The 'stone bed' is not formed by the subterranean dissolution of the chalk, for among the flints we often find bivalves in the position of life, and beneath them the chalk is here and there bored by *Pholas* and *Saxicava*."

I am bound to say I cannot think this description quite represents the facts as I have seen them in many visits. In the first place, to compare this continuous bed of flints overlying the chalk with the patches and insular areas now being formed on the foreshore occupied in some cases by an almost continuous pavement of paramoudras and in others by a similar pavement of very large unweathered and generally unbroken flints is most misleading. The greater part of the flints in the continuous beds overlying the chalk are rounded and weathered or broken, and it does not contain, except very rarely, large bizarre-shaped flints and paramoudras, but consists mainly of true rounded boulders, mostly not much larger than a cricket ball, lying, not in a kind of pavement, but heterogeneously mixed and forming a rude conglomerate, in which the contents become smaller and more rounded as we travel eastward until they become in places mere fine gravel. This bed ranges from a yard or more in thickness to a few inches, and is bound together by oxide of iron into its normal condition of a very hard tenacious conglomerate. It seems to me that in its continuity and in its contents and structure it differs entirely from the insular and detached areas covered with unweathered flints on the foreshore with which Mr. Clement Reid compares it, and any theory based on an analogy between them must fail.

Secondly, I cannot agree with Mr. Reid that this bed "does not necessarily belong to any one horizon." In the stretch of coast I am describing it is an absolutely unique feature, which catches the eye at once, from the contrast between its dark ochreous colour compared with the white chalk below it and the grey clay or loam or sand above it, and from its running continuously along the coast separating the clays and sands above from the chalk below and forming a most unmistakable horizon. Indeed, I do not well see how such a bed could be formed at any other horizon. Its great peculiarities are the shells it contains in many places and the iron oxide which has coloured it so deeply and has indurated it into a mass of 'hard pan.' This iron oxide, it seems to me, has been added to the bed, since it lay under the sea when its shell contents were accumulated, for it could hardly have accumulated in it when it was submerged and washed continually by the sea. Its accumulation in this bed is merely due to the fact that the rain-water has percolated through the Crag and drift sands above it, whose redness and yellowness are caused by the iron oxide they contain, and that the flow of this chalybeate water has been stopped by the chalk which has filtered it and compelled it to throw down the iron oxide in the covering layer of rounded and broken flints, and has thus accumulated a very respectable mine of iron-ore in this particular bed. This condition could only happen at the top of the chalk, and it seems to me that such a bed where it exists as it does here, must mark very clearly the horizon separating the chalk from its covering beds of more or less porous sand and loam.

Thirdly, while I do not dispute the fact that this bed, before it was saturated with iron oxide, lay once at the bottom of the sea, as its contained shells clearly show, I cannot quite understand how it can have resulted from the mere submarine dissolution of the chalk, which must be a very slow process indeed, except when it is being pounded by a shingle beach and must be very largely limited to the area where these waves act and not reaching the laminarian zone. Nor can I quite understand how the rolled and broken flints in it are to be thus explained. Such beds as have clearly resulted from submarine dissolution and still remain on the foreshore have hardly any rolled or broken stones in them, but the great uncouth flints and paramoudras are held tight and do not move, and are therefore not rolled or broken except in very exceptional cases.

I believe myself that the rounded flints and occasional quartzites in this bed of hard pan (as I will call it) are in their present form much older than the shells it contains and were rolled or broken possibly in the time of the Red Crag sea or perhaps even earlier, and that the bed in question must have a very different origin from the mere submarine dissolution of the chalky matrix of the flints. This, however, is a matter which must not detain us at present.

The point I wish to insist upon is that this bed is not, as Mr. Reid argues, matched by similar beds at other horizons elsewhere, but is, on the contrary, a unique feature, and it marks most graphically for us the present upper limit of the chalk as it is seen in the cliffs and on the foreshore and marks also the base of the Crag.

This hard pan is remarkable, as I have said, for containing in many places a large number of bivalves. Quite a large proportion of these are complete valves, and a large number again have both valves united, showing they are still *in sitû* in the position of life. They are jammed in among the stones, and are most clearly, as Mr. Reid says, where they actually lived. This again shows how different in essence the bed is from the insular areas of flints on the foreshore, which contain no whole shells and very few fragmentary ones.

It is perfectly plain, therefore, that since this bed was formed out of rolled materials, etc., and since it was lying at the bottom of the sea in *a quiescent condition* (otherwise the shells would have been reduced to powder), the level of the hard pan with its underlying chalk has been entirely and forcibly altered. These shells could not clearly live at a height of nine or ten or more feet above high-water mark as they now occur in many places in the cliff, but must have lived below low-water mark where the so-called laminarian zone of marine life is now found. The beds have clearly been thus dislocated in the latest geological period.

In more than one paper on the recent dislocation of the chalk in the Eastern Counties published in the GEOLOGICAL MAGAZINE I have, in fact, pointed out how recent and how very potent this dislocation of the chalk has been. No evidence of the fact could be plainer than that to which I am now drawing attention. For a long distance from the cliff end at Weybourne, as far indeed as near Sheringham, the hard pan and chalk are now several feet above high-water mark. East of Sheringham the chalk with its covering, after sinking for a short distance, is again raised several feet above high-water mark. It then sinks down again to the level of the shingle, and can be traced along the foot of the cliffs to beyond West Runton. This level of the shingle, again, is several feet above the level of the laminarian zone, so it is quite plain that from the end of the cliff at Weybourne at least to West Runton the chalk and its covering have been raised many feet, or rather yards, since the shells contained in the hard pan were living, which means since the greatest part of the living mollusca existed in the adjoining sea.

This, again, is quite plain from the outline and structure of the chalk beds below the hard pan. Their surfaces are in places meandering and not level, and in places they are arched up, as shown by the curved lines of the flints in the chalk, and as figured by Mr. Reid in his memoir. At intervals, where gaps occur in the cliffs, and their surface sinks down to that of the shingle beach, the chalk for a while disappears, as at Weybourne Mill, Hithe, etc. In these cases the chalk has either disappeared through a fold forming a synclinal dip, or from some disconnection and complete breach of a more violent kind. Apart from this the level of the chalk gradually sinks to a lower point as we move eastwards. East and west of Sheringham its surface is very irregular and broken. This is immediately before it disappears entirely from the cliff, and where it is found only on the shore at its foot.

The same irregularity in the surface contour of the chalk and the same broken and dislocated character of the same bed is found in the inland parts of the county, as has been shown by earlier writers whose observations I have collected in a previous memoir.

This last conclusion is attested by the various borings for wells which have been sunk in Norfolk, and by the exposures of chalk in chalk and marl pits. They show conclusively that the level at which chalk is reached in sinking varies very greatly, and varies in areas near one another, showing that it has been greatly disturbed and broken over a wide extent since it was deposited. Of this variation in depth at which the chalk is found in the county the Survey Memoirs afford ample evidence. The same conclusion is forthcoming again from the considerable number of great angular masses of detached chalk occurring among the drifts in various parts of the county, which in places are big enough to have permitted of chalk being quarried out of them; phenomena which have been noted by many observers, and the impressions to be drawn from which have been enlarged upon in my previous papers on the dislocation of the chalk in the Eastern Counties already referred to. In the country round Cromer and Sheringham I have lately again visited several of these pits. There is a fine one behind the mill at Weybourne; another near the road in a cutting through the hill between Weybourne and Salthouse; another behind the hill east of Beeston Hill; another near the upper gate of Mr. Upcher's park on the Holt road; a small one east of Cley, on the road to Sand; and more than one at Northrepps. In all these cases the irregularity of level at which the chalk occurs is remarkable. It is not easy to determine in many cases whether the chalk exists in a detached mass or forms the nucleus of the hill in which it is found, and has been merely raised up, but in either case the proof of some violent action is patent.

The occurrence of great masses of shelly Crag at Norwich, far from the sea and overlying the Chalk, and of other portions also at a considerable elevation in the Bure valley, shows even more forcibly how great has been the elevation and disturbance of the chalk in these latitudes since the Norwich or Weybourne Crag was deposited.

The same conclusion follows inevitably from the conditions under which the vast cakes and huge angular masses of chalk occur in the drifts at Beeston, West Runton, and elsewhere, a phenomenon which has attracted the attention of geologists for a long time and been the cause of endless discussion. From Weybourne to near Sheringham nothing is more remarkable in the cliffs than the scarcity of large flints or of masses of chalk in the clays and sands overlying the hard pan. So scarce are they that they may virtually be said not to exist at all except occasionally in the gravel sometimes capping the cliffs, and which is sometimes contained in pockets, more or less great, in hollows formed on the upper surface of the sands.

East of Sheringham the whole condition of things is changed, and thence to Cromer the cliffs are marked in several places, as the cliff sections displayed in the Survey Memoirs show, by the vast long cakes of chalk containing flints, which have been ridiculously called chalk boulders, and which, as I have said, have been the puzzle of every inquirer, and the cause of many fantastic theories on the part of those who dislike induction but love paradox and sensation in science.

In the sections illustrating the geology of Cromer cliffs attached to the memoir on the geology of Cromer, these long cakes of chalk between East and West Runton gap are duly represented, although on much too small a scale to show their real features. In the stretch of cliff between West Runton and the brickyard in Beeston cliff there is a particularly interesting and notable enclosure in the drift which is not noticed in the sections in question, nor, so far as I know, in the literature on the subject. It may be that it has only recently been exposed in the cliff, but this seems very improbable. Like the tabular cakes of chalk just mentioned, this included mass is also remarkable for its great length and small thickness, but what makes it much more notable is the disintegrated materials out of which it is composed. When I first saw it I was particularly puzzled, because I could see from the foot of the cliff only a long serpentinous line of chalk (true chalk and not made up) curved into a sinuous shape and extending for a great many yards, nowhere apparently more than a foot thick and thinning down to 4 or 5 inches. On climbing up the cliff I found that this enigmatical ribbon of chalk was covered with a stratum of hard pan formed of small flint pebbles and full of Weybourne Crag shell fragments, and over this again was a stratified bed of sandy and gravelly Crag, the whole united together and forming a continuous series of beds. The entire mass is more or less lenticular in shape in its thickest part, but stretches out on either side into a kind of ribbon and has been detached and transported *en masse*. Although the pebbles of flint are indurated by iron oxide, they are much more loose than elsewhere where the iron pan occurs at the foot of the cliff. There cannot be any doubt that we here have a case of a surface layer or rather skin of chalk having been stripped off violently from the chalk matrix, and with it the usual covering of the chalk as it occurs when *in situ* and undisturbed on the foreshore, that before it was moved this cake of mixed materials formed an integral part of the uppermost bed of the chalk with the Weybourne Crag attached, and that the detachment and portage of the whole mass took place after the deposition of the Weybourne or Norwich Crag.

I ought to add that this remarkable cake of conjoined chalk and crag is matched in the case of the longer and better known tabular chalk masses between East and West Runton Gap. On portions of two of these the same bed of hard pan or consolidated gravel occurs. In these cases the gravel is represented in the sections of the Survey Memoir lying on the chalk, but its significance is entirely overlooked, and, *mirabile dictu*, the gravel is labelled *glacial gravel*. What there is glacial about it defies conjecture. It is formed of small rounded flint pebbles with occasional quartzites, like all the other gravels of the upper crag, and, so far as I know, of nothing else, and is the exact equivalent of the hard pan as it exists similarly planted upon the chalk when the latter occurs with the crag in juxtaposition along great stretches of the coast. It is, in fact, a definite proof that these chalk cakes, like the serpentinous mass of chalk last mentioned, were violently detached after the deposition of the Weybourne Crag.

I may say that these tabular chalk cakes, like the mixed mass above named, have meandering or arched outlines, and that the once horizontal beds of flints in them have been bent into the same curves, which imply the exercise of similar forces as those in the chalk still *in sitû* and were doubtless induced at the same time.

It would be a great mistake to suppose that these enormous masses of detached chalk lying in and surrounded by later beds are a peculiar feature of the cliff sections only. They also occur in several sections far inland, as far, in fact, as Leicestershire and Northamptonshire, in several places having actually been used as chalk-quarries. What is perfectly plain is that the phenomenon they witness to, is that of a violent and notable dynamical movement, however caused, and which is to be put alongside the other proofs of similar dislocation and violent breakage already mentioned in this paper.

We have no reason to suppose that the movements involved belonged to different periods and occurred at different times. On the contrary, such evidence as is available, as we shall see, goes to show that it took place at one time. We have seen that on the coast this is shown to have been after the deposition of the so-called Weybourne Crag, whose shells are found in the red pan. The fact of the Norwich Crag and the so-called Bure Valley Beds (which are merely the local representation of the Weybourne Crag) occurring so far from the coast and at such a comparatively high level, and the fact that the chalk beds in the former place correspond to those between Weybourne and Runton, as Mr. C. Reid says (see Memoir on Cromer, etc.), is strong testimony to the fact that the dislocations of various kinds here referred to, and so notorious to every student of the district, were contemporaneous and occurred at the same geological epoch, namely, after the deposition of the Norwich or Weybourne Crag.

This view is, to some extent at least, that of the Geological Surveyors. Thus, speaking of the bent and distorted chalk at Trimingham, Mr. C. Reid says: "That this contortion is of Pleistocene date is proved by the similar disturbances of the overlying beds, and by the intrusion of tongues of Boulder Clay into the Chalk. Lyell was fully aware of this unconformity and gave illustrations of it; he mentioned the mixture of Chalk and Boulder Clay on the foreshore, and considered that the contortion must clearly have been formed subsequently to the deposition of the Drift" (Geology of Cromer, etc., p. 95).

What Mr. Reid here says of the local disturbances at Trimingham I would apply to the Chalk dislocations of all North Norfolk and its borders, which I claim to have all been contemporaneous and posterior to the deposition of the Newer or Norwich Crag. To sum up the case as far as we have gone, the evidence of violent change and movement and dislocation in the Chalk of Norfolk after the deposition of the latest Crag beds is very widespread and very cumulative. It would appear further incontrovertible from the available facts that when these newer Crags were being deposited the contour of Norfolk was quite different to what it is now, and that a considerable part of it was occupied by beds, not of curved and broken chalk as now, but of horizontally bedded chalk lying at the level of the laminarian zone upon which the Crag shells lived and the Newer Crag beds were deposited, and that it was after this time that the whole of it was subjected to violent forces which dislocated and broke it and gave it its present contour. These conclusions seem inevitable.

The next question that arises is what was the force or what were the forces which caused these dislocations and movements, and which occurred on this great scale not in remote geological time but, geologically speaking, only yesterday, at an epoch, in fact, when the possibility of such movements has been so continuously scouted by the champions of orthodox geology.

There are only two ways in which this widespread dislocation and destruction could take place. It must have been either by the application of force from the outside and from above, or by the exercise of subterranean energy. In regard to the former notion, which is the orthodox one, the difficulty is stupendous. We must not forget that the total thickness of the Chalk in this part of Norfolk must be very great, probably largely exceeding 500 feet, and further that chalk is a very tough material, offering great resistance to pressure. How we are to secure an instrument acting from above which could twist and curve this material into meandering curves, arching it here and depressing it into synclinal folds elsewhere, and could further break off with ragged edges and deeply wounded surfaces great angular masses and cakes of chalk, passes my comprehension. Yet the postulate has been gaily appealed to by most of the orthodox geologists without any attempt whatever being made to justify it.

The Rev. O. Fisher, who generally argues in a strictly inductive way, writing as far back as 1868, attributed phenomena such as we are discussing to the pressure exercised by large masses of material on the underlying beds. Thus he says *inter alia*: "in attributing contortions in the underlying beds to the deposition of masses of matter upon the surface, I would go to the extent of suggesting that the remarkable bluffs of chalk at Trimingham may have been upraised by some such action." Surely here we have a whole series of unverified premises! Where can we find a single instance of such contortions and breakage as we are discussing as the result of placing great weights on the surface of the earth? Take the Pyramids, or buildings like St. Paul's or St. Peter's, among human experiments, or turning to purely natural phenomena, take the innumerable examples we can find of perfectly horizontal beds lying under tremendous loads of superincumbent material much greater than any that can be appealed to as overlying the Chalk in Norfolk. Surely the idea is a purely transcendental one. How, again, is the pressure of such a mass, even if effective for the purpose of producing dislocations, to cause meandering contours and alternate arches and hollows in chalk beds several hundred feet thick, or how is it to break off vast masses from their matrix with raw and angular edges? Assuredly, if the pressure is sufficiently great, crushing will ensue; that is true enough, but has anyone attempted to calculate the amount of mere pressure that would be needed to crush the chalk, a problem which Mr. O. Fisher might easily have faced before offering an hypothesis so remote from probability. But even if he had faced it we should be no nearer. There is no sign whatever of mere crushing in these chalk cliffs and great chalk masses. The chalk in them and the lines of flint in them are quite intact, and so are the beds of consolidated gravel and finely laminated sand which in many places are adherent to them. We should expect if the pressure had been sufficiently great to be efficient at all that it would have crushed these chalk beds into powder, and not curved them and twisted them in this way, or broken them off with sharp edges. The whole process seems to me utterly fantastic and impossible. I am not alone in thinking so. In this instance I quite agree with Mr. C. Reid when he says: "The Rev. O. Fisher's theory of the forcing up of the beds by irregular deposition of masses of material on their surface seems inadequate to the formation of contortions on so vast a scale. It is doubtful whether anything less than a mountain piled on the surface at Trimingham would be sufficient for the contortion of 200 feet of underlying strata." This is quite judicious, although it understates the difficulty, but in the face of such a statement what are we to say of Mr. Reid's own theory? After thus demolishing the Rev. O. Fisher's notion that the chalk dislocations were due to the differential pressure of superincumbent masses of strata as quite inadequate, he proceeds, without any attempt at a physical analysis of the conditions of the problem, to apply the very same kind of explanation himself, only substituting ice for beds of rock or sand or clay. Assuredly, nothing can well be more inconsequent, for it merely adds to the difficulties instead of diminishing them. Let us analyze his argument. The distinction in Mr. C. Reid's mind seems in some way to rest on a notion that while the postulated superincumbent rocks, sands, or clays here referred to would be *ex hypothesi* stationary, ice is in a measure mobile, and he says the explanation of the broken and contorted condition of the chalk is only possible on the hypothesis of "a lateral thrust, or of a sliding pressure from above."

(*To be continued.*)

V.—TWO NEW SPECIES OF *EURYPTERUS* FROM THE COAL-MEASURES OF ILKESTON, DERBYSHIRE.

By HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S., F.G.S.

(PLATE XIII.)

BY the kindness of Mr. Henry A. Allen, F.G.S., of the Geological Survey of England, three examples of *Eurypterus*, in clay-ironstone nodules, showing impression and counterpart, together with a fragment of a fourth example, all from the Coal-measures to the north-west of Ilkeston, have been most obligingly lent me for description by their discoverer, Dr. L. Moysey, M.A., of St. Moritz, Ilkeston Road, Nottingham.

Remains of *Eurypterus* are extremely rare in the Coal-measures The earliest Carboniferous *Eurypterus* discovered and described was

E. Scouleri of Hibbert,[1] from a quarry at Kirkton, near Bathgate, West Lothian, in a fresh-water limestone containing much silica and associated with fronds of *Sphenopteris Hibberti.*[2] The first to be described in America was *Eurypterus* (*Anthraconectes*) *Mazonensis*, by Messrs. Meek & Worthen, from the Coal-measures of Grundy County, Illinois.[3] The next was in 1877, by Mr. Charles E. Hall, of the Geological Survey of Pennsylvania,[4] under the name of *E. Pennsylvanicus*, from the Lower Carboniferous rocks of Venango County, and another example from the Coal-measures of Cannelton. Pa., under the name of *Eurypterus* (*Dolichopterus*) *Mansfieldi.* These were noticed and refigured by Professor James Hall,[5] who added figures of Eurypteridæ from the Lower productive Coal-measures in Beaver Co. and the Lower Carboniferous Pithole Shale, Vernango Co. The additional species, noticed by Professor James Hall, were *E. Beecheri*, Hall (an Upper Devonian form from Warren, Pa.); *E. potens*, Hall, Carboniferous, Pa.; *E. stylus*, Hall, shale below Cannel Coal, Darlington, Pa.

A very interesting and well-preserved *Eurypterus*, named *E. scabrosus*, was discovered in 1886 in the Lower Carboniferous Series of Eskdale, Scotland, and figured and described in 1887.[6] Part of the body of another example, named *E. Wilsoni*, from the Coal-measures of Radstock, Somerset, was also figured and described by the writer.[7]

Other remains of *Eurypterus* have been referred to *E. Scouleri*[8] from the Carboniferous of Cape Breton. Another species, not determined, was noticed by Salter from the Carboniferous of Nova Scotia. A form doubtfully referred to *E. Scouleri* from the Upper Devonian of Kiltorcan, Ireland, and one named by Salter *E. pulicaris*,[9] from the Devonian of St. John's, New Brunswick; one from the Lower Devonian of Arbroath, *E. Brewsteri*[10]; one from the Passage Beds, Purton, Herefordshire, named *E. Brodiei*, H. Woodward, complete the Carboniferous and Devonian series.

In the Upper Silurian no fewer than 17 species of *Eurypterus* have been described, 10 being from Russia and North America, and 7 from Ludlow, Kendal, and Lanarkshire; the most perfectly preserved, however, are from North America, and from the Island of Oesel in the Baltic.[11] The dermal coverings of some of these

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[1] Trans. Roy. Soc. Edin., vol. xiii (1836), pt. 1, p. 280, pl. xii.

[2] H. Woodward: Mon. Pal. Soc. Merostomata, 1872, pp. 133, 180, pls. xxv–xxvii and text-figs.

[3] See Amer. Journ. Science, vol. xlvi (1868), p. 21; afterwards more fully illustrated and described by the same authors in the Reports Geol. Surv. Illinois, vol. iii (1868), p. 544.

[4] Proc. Amer. Phil. Soc., vol. vii (1877), p. 621.

[5] Second Geol. Surv. Pennsylvania: Report of Progress P.P.P., 1884.

[6] H. Woodward: Geol. Mag., 1887, pp. 481–484, Pl. XIII.

[7] Geol. Mag., 1888, pp. 419–421, Woodcut.

[8] J. W. Salter: Quart. Journ. Geol. Soc., vol. xv (1859), p. 232, pl. x.

[9] J. W. Salter: Quart. Journ. Geol. Soc., vol. xviii (1863), p. 346; vol. xix, pp. 78–79.

[10] H. Woodward: Geol. Mag., Vol. I (1864), p. 200, Pl. X, Fig. 3.

[11] Fr. Schmidt, "Die Crustaceenfauna der Eurypteren-schichten von Rootziküll auf Oesel. Miscellanea silurica, iii": Mém. Acad. Imp. Sci. St. Pétersbourg (vii), vol. xxxi, No. 5, 1883.

Swedish specimens have lately been obtained in so perfect a state of preservation that they have been mounted on glass by Professor E. J. G. Holm, and a series so prepared are preserved in the Natural History Museum, Cromwell Road.[1]

EURYPTERUS MOYSEYI,[2] H. Woodw., sp. nov. (Pl. XIII, Figs. 1, 2.)

Figs. 1 and 2 on our Plate XIII are drawn, slightly enlarged in each case, from one of the sides of two irregularly-shaped clay-ironstone nodules, which have been split open; Fig. 1 displaying also upon its inner surface, not only the Arthropod about to be described, but also the pinnule of a Neuropterid fern, attesting the near presence of land-conditions, as seen also on pl. iv, fig. 3, pl. vi, and pl. viii, fig. 2, of Professor Hall's figures of Eurypterids from the Carboniferous beds of Pennsylvania already referred to.

Our Fig. 1 shows clearly the semicircular fronted head-shield, with its truncated posterior border followed by seven rather narrow but transversely broad and arching post-cephalic segments. The head-shield carries the eyes, which are prominent and placed anteriorly and subcentrally on its upper surface; they are smooth (not facetted) and of the usual reniform outline. A raised semicircular ridge seems to unite them in front, but this is probably due to the squeezing upwards of the bases of two of the anterior pairs of endognaths; a detached portion of one of the palpi (*en.*) is seen on the left side of the head-shield, and two others on the right side.

Owing to the circumstance that the posterior portion of the cephalic shield has adhered to the counterpart of the nodule, the mouth organs on its under-side are more clearly exposed to view, and we see the oval metastoma, or post-oral plate (*m.*), occupying the centre of the space, having its attached hinder border rather below the posterior margin of the head, while its anterior, slightly notched, free extremity reaches to the centre of the head-shield. The broad basal joints of a pair of powerful ectognaths (*ec.*, *ec.*) flank the metastoma on either side; only a part of one of their swimming palps (*ec.*) is seen lying detached on the left side; perhaps the appendage labelled (*en.* 6) on the right side may be the other palpus, the distal spatulate extremity being in that case broken off, or concealed by the matrix. Endognath 5 (*en.* 5, Fig. 1) is a slender organ having only four of its original seven joints visible; the terminal joint being a simple and sharp spine.

The narrow median organ, or central appendage, of the opercular plate, the extremity of which is rounded, is seen in Fig. 1, *op.*, as a well-marked impression underlying the four anterior post-cephalic segments.

As in other species of this genus, the first segment following the head-shield is narrower than the rest; the three which follow are deeper, and increase gradually also in breadth; then follow three more, which become gradually narrower but do not diminish in

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[1] E. J. G. Holm, "Ueber die Organisationen des *Eurypterus Fischeri*, Eichw.": Mém. Acad. Imp. Sci. St. Pétersbourg, Phys.-Math. Cl. (VIII), vol. viii, No. 2, 80 pp., 10 pls., 1898.

[2] Named in honour of the discoverer, Dr. L. Moysey, M.A., of St. Moritz, Ilkeston Road, Nottingham.

depth. These seven segments forming the thorax (*pereion* of Spence Bate) give to the body a somewhat globular or rounded contour. Those which follow (probably seven in number) were greatly reduced in breadth, but increased somewhat in depth, ending in all probability in a more or less long slender ensiform telson. Figs. 1 and 2 have only eight and nine segments respectively preserved, the remainder of the abdominal series, which extended into the matrix beyond the edge of the clay-ironstone nodule, being lost.

In *Eurypterus*, as in so many other Arthropods, each somite is clothed in a chitinous or calcareo-chitinous envelope, an upper part (or *tergum*) and a lower part (or *sternum*) giving rise at their junction to small recurved epimeral plates or pleuræ on the lateral margins of each segment. These tergites and sternites, in fossilisation, have been pressed together, and are often somewhat displaced along the margins of the segments, but the outer upper surface can always be readily detected by the presence of rows of minute squamate markings so characteristic of all the Merostomata (see Figs. 1 and 2).

Although the head-shield in Fig. 2 is less well preserved than that of Fig. 1, and the eyes are very indistinct, there are portions, nearly in place, of at least four jointed endognaths or palpiform organs (*en.* 1, 2, 3, 4), which served as mouth organs and also as locomotory appendages, the last and most posterior pair, which are always the largest, being modified to serve as powerful swimming feet. Probably *en.* 3 and 4 may represent this pair of swimming feet, one of which has been in that case displaced from the right side. The basal joints of this posterior pair occupy in Fig. 2 the same position as in Fig. 1, being placed one on either side of the oval metastoma. The greater part of the opercular plate (*op.*), situate immediately behind the head, is exposed to view by the removal of the tergites of the first and second body-segments, leaving the left side and the central appendage uncovered. Two of the series of narrow abdominal segments following the broad thorax are preserved in Fig. 2; also the pointed recurved pleuræ or epimera on the right side of the seven thoracic plates, which are well shown and quite in order.

In the figures given by Professor James Hall of the American *Eurypterus Mansfieldi* from below the Cannel Coal, Cannelton, Pa., the epimeral pieces on the margins of the body-segments are shown to be produced into strongly recurved spinous processes (see particularly op. cit., pl. iv, fig. 3, and pl. v, figs. 3 and 11). These spinous lateral processes also frequently occur detached, and I have seen such from our own Coal-measures, but I do not think they were so prominent on the segments of *Eurypterus Moyseyi*.

Measurements.—Fig. 1. Length of head-shield 21 cm., breadth at base 26 cm.; breadth between eyes at back 10 cm., length of eye 4 cm.; length of metastoma 10 cm., breadth 8 cm.; length of median appendage to opercular plate 12 cm., breadth 4 cm.; length from base of metastoma to base of 7th segment 21 cm.; greatest breadth of thorax 29 cm., average depth of thoracic segments 5½ cm.; breadth of first abdominal segment 15 cm., depth 7 cm.

Fig. 2. Length of head-shield 17 cm., breadth of base 23 cm.; length of seven thoracic segments 25 cm., greatest breadth 26 cm.; length of

median appendage to operculum 8 cm., breadth 4 cm.; breadth of 1st abdominal segment 14 cm., length 7 cm.; metastoma, length 10 cm., breadth 7 cm.

In the specimens of *Eurypterus*, figured and described by Professor James Hall from Pennsylvania, the body-segments, especially those of the abdomen, appear to be more narrow and elongated than these Derbyshire specimens indicate. *E. Moyseyi*, for instance, has a more globular or rotund thorax, and the ornamentation is less spinose and the squamæ are more minute.

The thoracic segments figured by me (see GEOL. MAG., 1888, pp. 419–421) from the Coal-measures of Radstock, Somerset, evidently belonged (like the Scottish specimen named *E. scabrosus*) to a much larger form, at least twice, if not thrice, as large.

EURYPTERUS DERBIENSIS, sp. nov. (Pl. XIII, Fig. 3.)

This specimen is much smaller than the preceding examples and not very clearly preserved, being mixed with numerous detached and broken leaves of a fern; nevertheless, although at first doubtful, I am now inclined to regard it as being certainly distinct from *E. Moyseyi*, with which it was found associated.

The head-shield has the usual subquadrate form, rounded in front; the eyes, which are prominent and a little larger in proportion to its relative size, are placed somewhat closer together, and rather nearer the anterior margin than in *E. Moyseyi*. Two imperfect endognaths (*en.*) are seen on the right side of the head and one of the swimming feet (*ec.*) on the left side. The metastoma or post-oral plate (*m.*) is oval in form, its posterior border being hidden beneath the thoracic segments, which are squeezed together somewhat and have lost a part of their margins. There is a faint impression on the counterpart (not drawn) of a long median appendage belonging to the opercular plate seen beneath the thoracic sternites. What is very interesting is the presence of about six narrow but deep abdominal segments, having a crenulated ornamentation suggesting the presence of a row of marginal spines along the posterior border of each tergite. Similar plicæ are represented by James Hall in *E. Mansfieldi* (op. cit., pl. iv, fig. 3; pl. v, fig. 3; and pl. vi) from Pennsylvania.

Dimensions.—Total length of specimen 30 centimetres, greatest breadth of thorax 12 cm.; breadth of head 10 cm., length of head 6 cm.; length of thorax 9 cm.; length of abdomen 15 cm.; breadth of anterior segment 8 cm., length 4 cm.

This specimen (Fig. 3) differs slightly in the form of the head-shield, which is rather more quadrate than in Figs. 1 and 2; the body is more slender, and the plicæ (or spines?) along the posterior border of the abdominal segments are not seen on the posterior somites of Figs. 1 and 2. Possibly this might be considered as the male of the larger species, but the only other evidence is in the form of the imperfectly indicated median appendage of the opercular plate. Against this, however, is the fact that Figs. 1 and 2 differ probably quite as much from each other in the form of the opercular plate, and therefore Fig. 1 might equally well be deemed to be the male and Fig. 2 the female of the same species.

Under these circumstances, in order to avoid the inconvenience and suspense occasioned by a nameless fossil, I would suggest for Fig. 3 the specific designation of *Derbiensis* as serving also to mark geographical locality of this individual.

All the specimens are in the possession of the discoverer, Dr. L. Moysey, M.A., St. Moritz, Ilkeston Road, Nottingham, to whose courtesy I am indebted for permission to describe these very interesting Arthropods.

EXPLANATION OF PLATE XIII.

FIGS. 1 and 2.—*Eurypterus Moyseyi*, H. Woodward, sp. nov. Enlarged 1¼ times nat. size.

FIG. 3.—*Eurypterus Derbiensis*, H. Woodward, sp. nov. Enlarged 2½ times nat. size.

Clay-ironstone Coal-measures, all from a few feet below the "Top-Hard-Coal," 1¼ miles N.N.W. of Ilkeston, Derbyshire. Collection of Dr. L. Moysey, M.A.

en. endognath, one of the series of mouth organs (serving as maxillipeds) in Fig. 2 I have indicated *en.* 1, 2, 3, and 4.

ec. ectognath, indicate the basal joints (coxa) which form the chief organs of manducation; they form also powerful swimming organs (see figures in Professor Hall's work and in H. Woodward's Monograph on the Merostomata).

m. metastoma or post-oral plate, usually cordiform.

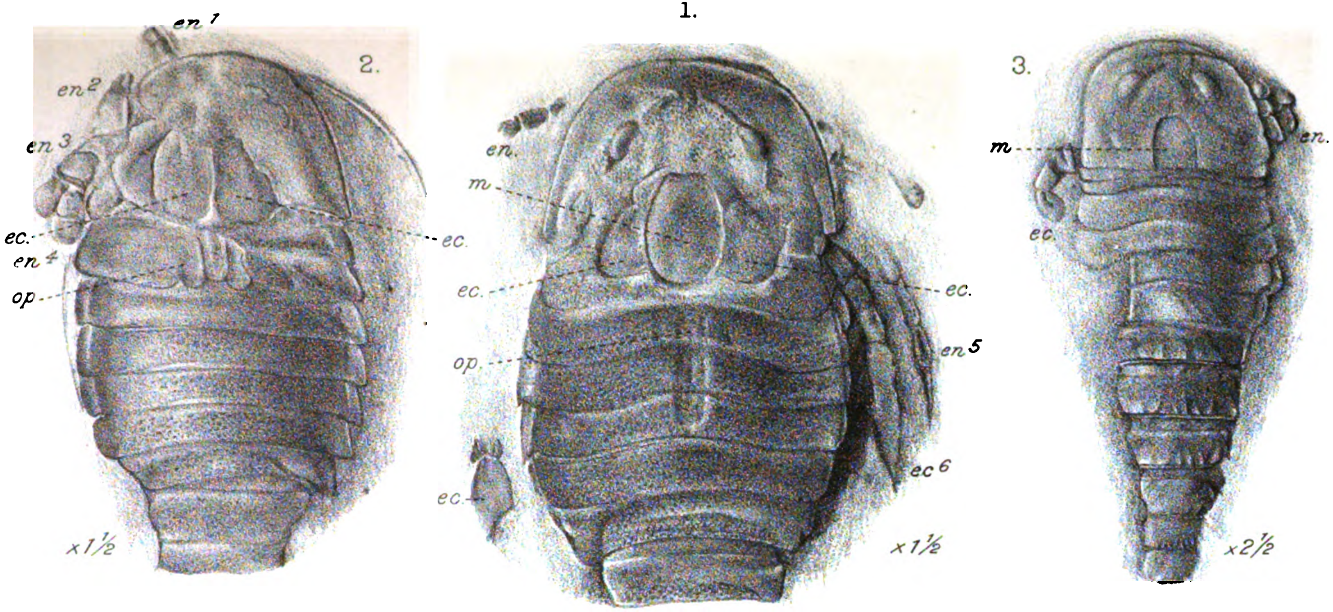
REVIEWS.

I.—THE ZONES OF NEOLITHIC TIMES.

STRANDLINIENS BELIGGENHED UNDER STENALDEREN I DET SYDÖSTLIGE NORGE. By W. C. BRÖGGER. With a German resumé, 11 plates, 2 maps, and 9 figures in the text. Norges Geologiske Undersögelse, No. 41. Kristiania, I commission hos H. Aschehoug & Co.; A. W. Bröggers Bogtrykkeri; 1905.

WE live in an age of zoning, but one may be pardoned for feeling surprise when one reads of the zoning of Neolithic deposits. The period embraced is geologically so short that one might on first thoughts have considered its subdivision into well-characterised zones as almost impossible. Yet this is what Professor Brögger has done, and it is of this that he gives us an account in the present volume. He has taken advantage of the rapid development of the skill and industry of man at this time, and has selected as his zone fossils the axe-heads of stone and flint which are found in the deposits of this age. He classifies them in certain types, according to their peculiarities of form, and each type he shows to be associated with a strand-line formed at some stage of recovery from the Littorina-Tapes depression. He is aided in this by the fact that the inhabitants of Norway during the early portion of the Northern Stone Age were fisher-folk, and lived mainly on the sea-shore. During its later stages they became more and more an agricultural and pastoral people, and their dwelling-places being no longer confined to the shore do not afford so exact a determination of its level. Yet even in this case it is possible to fix a limit for the height of the sea at that time.

A general account is given of the Littorina-Tapes depression and of



G.M. Woodward del. et lith. West, Newman imp.

Figs 1 & 2 Eurypterus Moyseyi, *H. Woodw.*, Fig. 3. Eurypterus, *sp.*
Coal-Measures, Ilkeston, Derbyshire.

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the strand-lines formed during recovery from it. The dwelling-places and other finds of stone axes are then described and classified, and the various types shown to correspond to the different shore-lines. An idea of the nature of the results obtained may be gathered from the following brief summary, giving the height in metres of the strand-lines at Kristiania which correspond to the several archæological stages:—

End of Older Stone Age (rough-hewn axes of 'Nöstvet' type), sea at 70 m.
End of Middle Stone Age (stump-necked round axe), sea at 55 m.
End of older part of Younger Stone Age (thin-necked axe), sea at 25 m.
End of Youngest Stone Age (thin-necked axe and shaft-hole axe), sea at 15 m.
End of Bronze Age, sea at present level.

The end of the Older Stone Age, or Nöstvet-time, corresponds with the maximum of the Littorina-Tapes depression. By comparison with the amount of elevation which took place during the Bronze Age and Younger Stone Age, the absolute durations of which have been estimated by archæologists in centuries, it has been found possible to make an estimate (admittedly uncertain) of the time of the Littorina-Tapes Maximum, the date arrived at being about 5000 B.C.

One cannot give this delightful book higher praise than to say that it is just such a work as we have learned to expect from the hand of Professor Brögger. It will be found essential to all, whether geologists or archæologists, who are interested in the history of post-Glacial time.

W. B. W.

II.—NEW MAPS OF THE GEOLOGICAL SURVEY OF SCOTLAND.

THE Survey has recently issued two sheets of the Geological Index Map of Scotland, scale 4 miles to 1 inch ($= \frac{1}{253440}$), viz.: Sheet 16 (size 21 by 13½ inches measured over the topographical work), colour-printed, 1907, price 2*s.* 6*d.*, and Sheet 17 (size 17 by 13½ inches), colour-printed, 1907, price 2*s.* 6*d.*

Sheet 16 includes Wigtonshire, Kirkcudbrightshire, part of Ayrshire, the south of Arran, and the south of Kintyre. In ascending order the rocks shown are Metamorphic Rocks (in Kintyre), comprising Green Beds, Limestone and Undifferentiated Schists; Lower Silurian (Arenig, Llandeilo-Caradoc); Upper Silurian (Llandovery-Tarannon, Wenlock-Ludlow); Old Red Sandstone (Lower, Upper); Carboniferous (Calciferous Sandstone, Carboniferous Limestone Series, Moor Rock (Millstone Grit), Coal-measures); Trias (Sandstones, Marls); Recent (Marine and Fresh-water Alluvium, Peat, Blown Sand). The igneous rocks are Volcanic Rocks, Intrusive Massive, including Granite[1] (Felsite, Porphyrite, Andesite), (Diorite and Hyperite), Basalt and Dolerite in dykes and in sheets, Gabbro,[1] Serpentine and Peridotite,[1] Fragmental, Agglomerate in necks, Extrusive Andesitic Lavas, Basaltic Lavas, Tuffs.

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[1] Usually considered to be plutonic.

Sheet 17 (next sheet to east of Sheet 16) includes part of Kirkcudbrightshire, Dumfriesshire, Roxburghshire (the eastern half of the town of Dumfries). More than half of the area of the map is blank as representing part of England. This is a pity. The good example set in Sir A. Geikie's Map of England and Wales and in the maps of Stieler's Hand Atlas of giving full detail of all the country within the sheet should have been followed. The rocks represented are Lower Silurian (Arenig, Llandeilo-Caradoc); Upper Silurian (Llandovery-Tarannon, Wenlock-Ludlow); Old Red Sandstone (Lower, Upper); Carboniferous (Calciferous Sandstone, Moor Rock, Coal-measures); Trias; Recent (Marine and Fresh-water Alluvium, Peat); Volcanic Rocks (Intrusive Massive), Granite (Felsite, Porphyrite, Andesite), Basalt and Dolerite in dykes and in sheets (Intrusive Fragmental), Agglomerate in necks (Extrusive), Andesitic Lavas, Basaltic Lavas, Tuffs.

Compared with Sir A. Geikie's, 10 miles to 1 inch, Geological Map of Scotland, the amount of detail shown on these sheets with 6¼ times the space is not as great as might have been expected.

B. HOBSON.

REPORTS AND PROCEEDINGS.

I.—GEOLOGICAL SOCIETY OF LONDON.

April 17th, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

Proposed Election of Women Associates of the Geological Society of London.—The President announced that a Special General Meeting would be held on Wednesday, May 15th, 1907, at 7.30 p.m., for the purpose of considering and voting on a proposed new section, and alterations in existing sections, of the Byelaws.[1]

The following communications were read:—

1. "The Toadstones of Derbyshire, their Field Relations and Petrography." By Henry Howe Arnold-Bemrose, J.P., M.A., F.G.S.

The district over which the Toadstones are seen may be divided into three main areas of volcanic activity, between which there are no exposures of igneous rock.

I. The North-Western or Miller's Dale Area.
II. The South-Eastern or Matlock Area.
III. The South-Western or Tissington Area.

In each of these areas there are lava-flows, bedded tuffs, and volcanic vents, and in the Miller's Dale and Matlock areas several intrusive sills. In the Miller's Dale and Matlock areas the igneous rocks are, with the exception of the Hopton vent, entirely in the Mountain

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[1] May 15th, 1907. At the Special General Meeting held on this day the proposed new Byelaws for the Election of Women Associates were submitted to the Fellows, and after an animated discussion the proposition was put to the vote and lost; 32 Fellows voting for and 34 against the motion.

Limestone; but in the third area they are mostly in the Yoredale Shales, and lava plays only a subordinate part. In the Miller's Dale area the upper lava is the thicker, and extends over a greater district than the lower, while in the Matlock area the converse is true. In the former area the lavas are separated by about 150 feet of limestone, in the latter by about 80 to 100 feet. The upper lava of Miller's Dale is on a lower horizon than the lower lava of Matlock, and the limestone above it contains at least two bands of interbedded tuff. The lavas are vesicular and amygdaloidal in structure, and often very much decomposed. They contain olivine, augite, and felspars, magnetite and iron-oxide; the felspars are often present in two generations. The sills are, for the most part, ophitic olivine dolerites, and pass from a very coarse-grained dolerite through the intervening stages into a fine-grained dolerite or basalt; they are similar in structure to certain Tertiary dolerites. The following vents are described:—In the north-western area, those at Speedwell, Monks Dale, and Calton Hill; in the south-east, at Cracknowl, the Grange Mill vents, Ember Lane, Moor Lane, and the Hopton vent; in the south-west, Kniveton Wood Cottage, Woodeaves, and Wibben Hill. The majority of the vents are composed of volcanic agglomerate; but the Calton vent, near Miller's Dale, is a typical basalt with a small portion of agglomerate, and the Hopton vent is a breccia of basalt fragments. The Toadstones have all been mapped on the 6-inch scale, and petrological accounts of the different rocks are furnished.

2. "Data bearing on the Age of Niagara Falls." By Professor Joseph William Winthrop Spencer, A.M., Ph.D., F.G.S.

The author has been engaged in investigations for a monograph on Niagara Falls, to be published by the Geological Survey of Canada. Soundings at all the points of great changes in the Gorge have been successfully undertaken, borings were put down for the exploration of buried valleys, and instrumental surveys made of the original river banks and the physics of the stream. The mean recession of the crest-line of the Falls is found to be 4·2 feet a year under existing conditions, and this rate has approximately obtained for 227 years. But this rate will not give the age of the Falls, on account of former great variations in the volume of the river and in the height of the Falls themselves. The chief change in volume of water depends on the fact that originally Lake Erie alone was discharged over the Falls, when the supply of water was only 15 per cent. of the present discharge. Lake Ontario, too, stood at a higher level, and thus the cutting back from Queenstown to Foster's Flats was effected with a small water discharge and, at first, a low head. After an uplift which raised the crest of the fall considerably above Lake Ontario, a slight depression followed which 'drowned' part of the lower gorge. This cutting is calculated to have taken 35,500 years for a distance of 14,400 feet. Above Foster's Flats the sudden widening indicates the inflow of the other lakes into Erie, greater water discharge, and greatly increased rapidity of recession. The changes in height of the Falls and resistance of the rocks are examined in detail, and the small influence of pre-Glacial filled channels estimated. The Whirlpool is on the site where the recession broke down the partition separating the head of the Whirlpool - St. David's buried gorge, and began to empty out the contents of this valley. The cutting with the full power of the water of the four lakes varied at times according to the height of the fall, and is calculated to have occupied only 3,500 years, for the cutting back of about 4 miles above the head of Foster's Flats. Thus the entire age of the Falls is given as 39,000 years.

II.—MINERALOGICAL SOCIETY.

Tuesday, March 19th.—Professor H. A. Miers, F.R.S., President, in the Chair.

On the silver deposit or Sedgman lode in the Perran Mine, Cornwall, by F. H. Butler. The lode runs through killas in an approximately north and south direction. The silver ore, consisting almost solely of cerargyrite, occurs in compact masses, or finely disseminated in a gossany limonite. Splintery and ferruginous quartz, the "cab-course," is always a well-developed feature in the richest parts of the lode. The distribution of the cerargyrite, to the depth of 18 fathoms to which the mine has been worked, is roughly in accordance with the surface contour of the land; but segregations have also taken place along a series of lines running from above downwards. The source of the chlorine, the author suggests, might be sea-water that has reached abyssal regions.—On the minerals of the Silvermines District, Co. Tipperary, by A. Russell. The mines extend along an east and west line of fault in which Silurian, Old Red Sandstone, and Carboniferous rocks are brought into juxtaposition. Along its course in certain places mineralisation has taken place resulting in contact lodes and metasomatic deposits. In the Ballygowan South mine is an interesting occurrence of hemimorphite, the only one of the kind known in the United Kingdom. The mineral is found in brilliant crystals lining cavities in limonite. The gossan also contains irregular masses of argentiferous galena, partially altered to cerrusite. At the Ballynoe mine copper pyrites, galena, and barytes form a lode between walls of Silurian and Carboniferous Limestone. At the Gortnadyne mine argentiferous tetrahedrite is found with copper pyrites and cerrusite ("cat-tooth ore"). An extensive series of old open workings of galena can be seen at the Shallee East mine.—On Baddeleyite from Ceylon, by G. S. Blake and G. F. Herbert Smith. Three brilliant crystals of the mineral were picked out from a number of specimens of the heavy minerals from the gem-districts of Ceylon which were sent to the Imperial Institute in 1905. Of the three crystals, one possessing only the prism zone was used for analysis, and found to contain nearly 99 per cent. of zirconia. On the two other crystals, one of which was a twin, were observed eleven forms, including one new one (210).—Zinciferous Tennantite from the Binnenthal, by R. H. Solly and G. T. Prior. Crystals of tennantite, one of which was a large cube, with faces deeply striated parallel to small tetrahedral faces, were found on analysis to contain nearly 8 per cent. of zinc.—On Strüverite, a new mineral by F. Zambonini and G. T. Prior. This new mineral was found in detrital masses of pegmatite near Craveggia in North Piedmont. Crystallographically it is very similar to rutile and tapiolite with axial ratio $a : c = 0{\cdot}6456$. Some of the crystals are elongated along the pyramid edge and are probably twins similar to those of ilmenorutile. The mineral is black and opaque, and has a specific gravity of 5·59. It contains titanic acid, zirconia, oxide of iron, and niobic and tantalic acid. The result of analyses suggests the formula $3\,FeO\,(Ta\,Nb_2)\,O_5$, $4\,ZrO_2$, $9\,TiO_2$, which may be written as a mixture of the three molecules $Fe\,(Ta\,Nb_2)\,O_5$, $Fe\,Zr\,O_2\,O_5$, and $Ti\,Ti_2\,O_6$ in the proportion of 1 : 2 : 3. Chemically it is very similar to ilmenorutile, but contains about 28 per cent. of ZrO_2, replacing part of the TiO_2.

CORRESPONDENCE.

PROFESSOR C. D. WALCOTT, LL.D., For. Mem. Geol. Soc.

Sir,—At the annual meeting of the Board of Regents of the Smithsonian Institution, held on January 23rd, 1907, Charles Doolittle Walcott, LL.D., was duly elected Secretary of the Smithsonian Institution, to succeed the late Samuel Pierpont Langley.

Melville W. Fuller,
Chancellor of the Smithsonian Institution.

Smithsonian Institution, Washington.

MRS. AYRTON'S THEORY OF RIPPLE-MARK.

Sir,—I am grateful to Mrs. Ayrton for having replied to my note of despair in the Magazine for February last. Our sole object is the truth in a question of small account with physicists, but of great importance to geologists. Owing to the action of the Royal Society and of the British Association in having Mrs. Ayrton's new theory presented to the scientific public in a demonstration at a conversazione, in a lecture to a section, and in a very short abstract in the Proc. Roy. Soc., there is next to nothing on public record, as even Mrs. Ayrton's abstract of her British Association lecture was not published in the Report, so there is little to discuss.

In her letter Mrs. Ayrton writes: "I actually showed at the lecture a series of periodically oscillating waves moving in one direction over a fixed bottom, and expending themselves on a sandy shore, and proved that under such waves ripples formed exactly as they did *in the moving tank* with vertical sides."

Mrs. Ayrton's own description of this experiment is as follows:—"I can imitate exactly the sand ripples *on the sea-shore* with water running in one direction only, if I slope the sand so that the water runs up it, as it does on the sea-shore, and if by means of a paddle I send a series of waves along the water in the direction in which it is running, if, in fact, I imitate the incoming tide." (Abstract, p. 3. Italics are mine throughout.)

It is most important to note that, as stated, the ripples thus made are like those made on the shore, but they are dissimilar from those made in the tank. Mrs. Ayrton is explicit on this point. She says, and very truly, with reference to the tank, that "the sand has heaped itself up in the middle of the trough, having a contour *very unlike* sea-shore ripples." (Abstract, p. 4.)

The paddle experiment made the nearest approach to sea-shore conditions, but it is practically impossible to make oscillating waves of uniform period by hand, and a paddle is a most unsuitable instrument for the attempt.

Had Mrs. Ayrton read a paper on so novel a subject in the usual way there would have been a most valuable discussion on it, as there were members present of both the British Association Committees that have investigated ripple-mark, viz., that on "Waves and Currents in Estuaries" and that on "Terrestrial Surface Waves and Wave-like Surfaces."

In a letter to the Magazine in December, 1904, I pointed out that all that was needful was a conference between Mrs. Ayrton, Sir George Darwin, Prof. Osborne Reynolds, and Dr. Vaughan Cornish, and that a unanimous report might easily be arrived at. Since then, however, the Royal Society have authoritatively approved Mrs. Ayrton's views on the general subject of ripple-mark, and have thereby inferentially disapproved of the aforesaid eminent authorities.

I only wish Mrs. Ayrton could be prevailed upon to experiment with waves of regular period running on a beach. The original suggestion was made by the late Mr. William Froude, F.R.S. My own small experiments did little, but they showed how much could be done with suitable tanks and motors to reproduce marine phenomena.

A. R. Hunt.

April 10*th*, 1907.

UINTACRINUS IN THE LONDON BASIN.

Sir,—It may interest your readers to know that I have at last found *Uintacrinus* in the London Basin, near Orpington. The specimens have been submitted to Mr. Sherborn, who writes: "I have no hesitation in identifying your specimens as *Uintacrinus*, because you send me well-preserved plates as well as large and small arm-ossicles. Hearty congratulations; you have worked hard enough for the discovery of this zone." I am now engaged in working out the area of the exposure.

G. E. Dibley.

April 23*rd*, 1907.

OBITUARY.

JOHN FRANCIS WALKER, M.A., F.L.S., F.G.S., F.C.S.

We deeply regret to record the death of our valued friend and fellow-worker in geology for so many years, John Francis Walker, who died rather suddenly at his residence, 45, Bootham, York, on 23rd May, aged 66. We hope to give a suitable notice of his work next month.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. VII.—JULY, 1907.

ORIGINAL ARTICLES.

I.—NOTES ON THE INVERTEBRATE FAUNA OF THE UITENHAGE SERIES IN CAPE COLONY.

By F. L. KITCHIN, M.A., Ph.D.

(Communicated by permission of the Director of the Geological Survey of Cape Colony.)

THE rich invertebrate fauna of the Uitenhage Series has long attracted attention, owing to the conspicuous nature of some of its components and the divergence of opinion which has arisen in the various attempts to bring it into correlation with Secondary faunas in the European area. A recent examination of the fossils collected from the Uitenhage Beds by the Geological Survey of Cape Colony has afforded an opportunity of reconsidering, in the light of extended knowledge, the conclusions of those who have previously studied this question of correlation. A comparative study of the fauna, with an account of some new species, based principally upon the materials collected by the members of the Survey, will shortly be contributed to the fourth volume of the "Annals of the South African Museum"; but in the meantime, the following brief notes, in which are embodied some of the principal results, may be of interest to a wider circle of readers.

The most comprehensive published accounts of the Uitenhage Beds, including the results of the recent surveys, are those written by Mr. A. W. Rogers and Professor E. H. L. Schwarz.[1] As regards the affinities of the marine fossils, the view that these indicate a Lower Cretaceous age has been most convincingly upheld in the palæontological studies of Krauss and Neumayr,[2] whose opinion is the one which is now most widely accepted. Sharpe and Tate,[3] on the other hand, believed the fauna to be of Jurassic age, and their view has until recently continued to find adherents. A few authors have suggested that the series may be in part Upper Jurassic and in part Lower Cretaceous.

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[1] Rogers & Schwarz, "Report on the Survey of parts of the Uitenhage and Port Elizabeth Divisions": Ann. Rep. Geol. Comm., 1900, p. 3; Cape Town, 1901. Rogers: "An Introduction to the Geology of Cape Colony," pp. 281–318, 1905. Rogers, "Geological Survey of parts of the Divisions of Uitenhage and Alexandria": Ann. Rep. Geol. Comm., 1905, pp. 15–33, 45; Cape Town, 1906.

[2] F. Krauss, "Ueber einige Petrefacten aus der untern Kreide des Kaplandes": Nova Acta Acad. Cæs. Leop.-Carol. Nat. Cur., vol. xxii, pt. 2, p. 439; Bonn, 1850. M. Neumayr, in E. Holub & M. Neumayr, "Ueber einige Fossilien aus der Uitenhage-Formation in Süd-Afrika": Denkschr. d. k. Akad. Wiss., Math.-Nat. Classe, Band xliv, p. 267; Vienna, 1882.

[3] D. Sharpe, "Description of Fossils from the Secondary Rocks of Sunday River and Zwartkop River": Trans. Geol. Soc. Lond., ser. II, vol. vii (1856), p. 193. R. Tate, "On some Secondary Fossils from South Africa": Quart. Journ. Geol. Soc., vol. xxiii (1867), p. 139.

The great majority of the invertebrate fossils collected from the Uitenhage Beds consist of Mollusca, and have been obtained from localities in the valleys of the Sunday's, Zwartkop's, and Coega Rivers. A more detailed examination of the fauna than that undertaken by previous writers fully corroborates Neumayr's conclusion that a large percentage of the Mollusca show affinity to Cretaceous rather than to Jurassic forms. There is, moreover, abundant evidence in support of the opinion of those who have ascribed to the Uitenhage Series a Lower Cretaceous age, although, as might be expected, there are a few bivalve forms which bear a somewhat close resemblance to familiar Jurassic types. It will suffice, however, to mention the presence of *Holcostephanus* (sensu stricto), the restricted group to which V. Uhlig and F. Suess have applied Pavlow's name *Astieria*, typified by *H. astierianus* (d'Orb.); *Hamites*; *Crioceras*; *Bochianites*; *Hoplites* (sensu lato), here represented only by *Acanthodiscus*, Uhlig, and perhaps also *Solgeria*, Uhlig; *Trigoniæ* of the divisions Scabræ and Pseudo-quadratæ; *Ptychomya*; *Thetis*, and *Solecurtus*. All these, so far as we know, are confined elsewhere to the Cretaceous rocks, and taken together, they give most decisive evidence of a Lower Cretaceous age. In Europe, *Holcostephanus* (sensu stricto) is almost wholly, if not entirely, confined to strata of Upper Valanginian and Lower Hauterivian age, and this genus is so richly represented in the Uitenhage Beds as to suggest strongly the soundness of a correlation with this part of the Neocomian stage. It has been frequently stated that *Holcostephanus atherstoni* (Sharpe), a Uitenhage species, actually occurs in the Lower Hauterivian of Europe; and although a careful examination of the evidence fails to bear this out, there can be no doubt that several *Holcostephani* in Cape Colony are intimately related to certain European forms. The remains of plants found in the Uitenhage Beds do not give such definite indications of geological age as the Mollusca, but it will be remembered that Professor A. C. Seward has expressed the belief that the balance of evidence furnished by the plants is in favour of a Wealden age.

It becomes a matter for some astonishment that Tate should have expressed so positively the opinion that the Uitenhage fauna is of Jurassic character, and should have arrived at the curious conclusion that these supposed 'Oolites' of South Africa represent the whole of the Jurassic rocks of Europe with the exception of the Upper Oolites, and illustrate an intermingling of palæontological types which are analogous to, or identical with, those distributed in successive zones in Europe. A study of the actual specimens upon which Tate based these conclusions shows clearly that he failed to see the true significance of the Cephalopoda, and that while making use of some bivalve types little adapted to serve the purposes of a critical correlation, he was further misled by several quite erroneous identifications.

Restricting our attention to the marine development of the Uitenhage Beds, it may be stated confidently that there is no palæontological evidence to show that even a part of the series is of earlier age than Neocomian. Those very forms which, if taken alone, might with some justification have been thought to indicate a Jurassic age, occur relatively high up in the series in association with shells of undoubted Neocomian type. On the other hand, some of the more characteristic marine forms have been shown by Mr. Rogers to occur near the base of the great Sunday's River sections as well as at higher horizons, and to have a much more extensive vertical range in the series than was formerly suspected. The closely similar nature of the marine fauna found at various horizons, together with other evidence, points to conditions of relatively rapid deposition. This unity of character, as shown by a study of the whole fauna, and also the fact that the Surveyors failed to find evidence for zonal differentiation which might be utilised in establishing any scheme of palæontological subdivisions in the series, seems to indicate without doubt that a very restricted time-period is represented by the whole of the marine beds. In considering the relations of the fresh-water beds to the strata of marine origin, Messrs. Rogers and Schwarz have sufficiently emphasised the part played by rapid contemporaneous variation of facies, and have shown how this factor precludes even a broad, generally-applicable classification, based upon a consistent succession of fresh-water and marine beds.

Representatives of the Lamellibranchiata largely preponderate among the Uitenhage Mollusca, and many of them provide data which usefully supplement the more desirable evidence afforded by the cephalopod-types, in the question of a correlation with European standards. When, however, we seek to trace relationships between the Uitenhage molluscs and those of Lower Cretaceous deposits situated in extra-European regions, it becomes necessary to rely almost entirely upon the evidence of the lamellibranchs, leaving out of account the fact, recognised by Pavlow and Uhlig, that some of the *Holcostephani* of the Uitenhage Series show near affinity to *H. schenki* (Oppel), from the Spiti Shales. Certain lamellibranchs, some of which are well-characterised forms, point to the relationship which existed between this development of the Neocomian in Cape Colony and the Oomia *Trigonia*-beds in Cutch, the strata yielding *T. ventricosa* (Krauss) in the Godavari district and in Hazara, the Neocomian deposits in German East Africa, and the Lower Cretaceous strata of presumably like age in Chili, Bolivia, and the Argentine Republic. In making these comparisons, important significance must be attached to the evidence of some of the *Trigoniæ*, notably of the divisions Pseudo-quadratæ and Scabræ.

F. Stoliczka, W. Waagen, O. Feistmantel, W. T. Blanford, and R. D. Oldham, all drew attention to the apparently close relationships existing between some of the bivalves in the Oomia Beds of Cutch and certain species in the Uitenhage Series, and the recent study of these faunas has shown that the evidence for such relationship is, in truth, of a very striking character. It is well known that a species of *Trigonia* which occurs very abundantly in the Oomia Beds was referred by the Indian geologists to *T. ventricosa*, first described by F. Krauss from the Zwartkop's River, Cape Colony. Although many of the

Indian specimens show a rather less degree of inflation than individuals representing the average characters of the species in South Africa, I do not consider that the points of distinction are such as to warrant specific separation, or even to permit the certain recognition of two well-defined local races. Should, however, the correctness of this opinion be called in question, the very close resemblance between the shells ascribed to *T. ventricosa*, from these widely separated habitats, must retain the strongest significance, when viewed in connection with the evidence for relationship between some of the associated forms in the one area and certain of those in the other. Several bivalves of the Uitenhage Beds, including such specialised forms as *Cucullæa kraussi*, Tate, and *Seebachia bronni* (Krauss), have very closely comparable, and perhaps identical, representatives in the Oomia group, and a new *Trigonia* from the Sunday's River Beds, belonging to the specialised and short-lived group Pseudo-quadratæ, bears a close resemblance to *T. mamillata*, Kitchin, a member of the same division of the *Trigoniæ*, from Cutch. The association of these Indian forms with a large *Gervillia* which closely resembles *G. dentata*, Krauss, has already been made known. The striking similarity between the *Trigoniæ* of the group of *T. v-scripta*, Kitchin, in the Oomia Beds, and the group of *T. vau*, Sharpe, in the Uitenhage Series, has been discussed elsewhere,[1] and while the adult stages in the members of the two groups probably illustrate homœomorphy, the presence of these analogous forms only serves to emphasise the remarkable aspect of similarity shown when we place side by side the identical and proximate types in the faunas of these widely separated areas. A review of the evidence so far available must certainly lead to the inference that these faunas in South Africa and India are approximately contemporaneous, and that the lines of intercourse between the two areas at that time were probably much more direct than was believed by Neumayr, W. T. Blanford, and others, to be the case. The evidence for the age of the Uitenhage fauna is so decisive that it becomes necessary, by means of this indirect correlation, to refer the *Trigonia*-bearing beds of the Oomia group to the Neocomian.

In the case of the Neocomian fauna in German East Africa which G. Müller believes to be related to that of the Uitenhage Series,[2] the evidence is of a somewhat less satisfactory character, but I am of opinion that the indications are sufficiently clear to show the correctness of Müller's view. Here, again, peculiarly characterised *Trigoniæ* are a special feature in the fauna, and some of these recall Indian and South African forms. For example, *T. kühni*, G. Müller, possesses characters which appear to indicate relationship to *Trigoniæ* of the group of *T. vau*, Sharpe, or the group of *T. v-scripta*, Kitchin, while *T. beyschlagi*, G. Müller, very closely resembles *T. crassa*, Kitchin, a degenerate costate form which occurs abundantly in Cutch. Another *Trigonia* has been referred by Müller to *T. ventricosa* (Krauss), and a large *Gervillia* is very closely comparable with *G. dentata*, Krauss, if it is not actually identical with it.

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[1] F. L. Kitchin, "The Jurassic Fauna of Cutch," vol. iii, pt. 2, No. 1, Genus *Trigonia*, p. 66: Palæontologia Indica, ser. ix (1903).

[2] G. Müller, "Versteinerungen des Jura und der Kreide": Deutsch-Ost-Afrika, Band vii, pp. 514–571; Berlin, 1900. F. L. Kitchin: op. cit., p. 121.

A search for traces of the characterising features of the Uitenhage fauna among the Lower Cretaceous fossils described from South America also reveals evidences of a suggestive kind, as recognised by several authors. From the Belgrano Beds in Patagonia, T. W. Stanton[1] has described two *Trigoniæ* which at once recall South African forms. *T. subventricosa*, Stanton, appears to be nearly allied to *T. ventricosa* (Krauss), and *T. heterosculpta*, Stanton, not only exhibits a peculiar type of adult ornamentation comparable with that exemplified by *T. vau*, Sharpe, and another related South African form, but its adolescent characters show that there is in all probability true relationship with this group of *T. vau*. Here, again, in the Belgrano Beds is found an associated *Gervillia* of large dimensions which does not seem to be widely removed from *G. dentata*, Krauss, of Cape Colony. From Chili, R. A. Philippi has described *Trigoniæ* which share the characters of peculiar sculpture and siphonal prolongation exhibited by the group of *T. vau*, Sharpe, and are probably related forms. The *Trigoniæ* of the group Pseudo-quadratæ described by G. Steinmann, R. A. Philippi, and C. Burckhardt from Lower Cretaceous beds in Bolivia, Chili, and the Argentine Republic, form an important connecting link with the Uitenhage fauna. *T. transitoria*, Steinmann, a member of this well-marked group, occurs with significant associates in the *Trigonia*-beds of Neocomian age exposed on the left bank of the Rio Agrio opposite Las Lajas, Argentine Republic.[2] These beds yield another member of this group of *Trigoniæ*, and also a species which very closely resembles *T. conocardiiformis* (Krauss), one of the most characteristic forms in the Uitenhage fauna. *T. eximia*, R. A. Philippi, from the Tinguirica valley in Chili, appears to be very closely related to these. The Chilian shells ascribed by Bayle and Coquand to *Ostrea couloni* bear a considerable resemblance to *Exogyra imbricata*, Krauss, of South Africa, with which Coquand himself later ventured to identify them. Accompanying this oyster in Chili is *T. delafossei*, Bayle & Coquand, the resemblance of which to *T. ventricosa* (Krauss) has been remarked upon by J. Lycett, W. Paulcke, and myself.

From this brief sketch it may be seen that certain groups of bivalves which form characterising elements as yet unknown to occur in Europe, have a remarkably wide distribution in a Neocomian development of southern type. Thus, *Trigoniæ* of the group Pseudo-quadratæ occur in India, Cape Colony, and South America; *Trigoniæ* of degenerate costate type, unknown elsewhere, are found in Cutch and in German East Africa; *Trigoniæ* of the groups of *T. v-scripta* or *T. vau* occur in Cutch, German East Africa, Cape Colony, and South America; *Trigoniæ* of the type of *T. ventricosa* are also met with in India, East Africa, Cape Colony, and South America; the remarkable form *T. conocardiiformis* has a close counterpart in South America; the genus *Seebachia* is known from Cutch and Cape Colony, while a species of *Cucullæa* which exhibits some striking distinguishing features has a similar distribution, and, like *Seebachia*, is without any near representative in the European area. The distribution of *Gervilliæ* of the type of *G. dentata* and large *Exogyræ* resembling *E. imbricata* may perhaps also be allowed to have some significance when considered in relation to the occurrence of the forms with which they are associated.

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[1] T. W. Stanton: Rep. Princeton Univ. Exped. to Patagonia, 1896–1899, vol. iv, pt. 1, Marine Cretaceous Invertebrates, pp. 18, 20, 1901.

[2] C. Burckhardt, "Beiträge zur Kenntniss der Jura- und Kreideformation der Cordillere": Palæontographica, Band L (1903), pp. 72–75.

These, in brief, are some of the more significant facts which must be borne in mind when we consider the broad questions of distribution which arise from a comparative study of the Uitenhage Mollusca. Having regard to the manner in which a number of the ammonoids from the Sunday's River Beds permit of close comparison with related European types, it is surprising that these South African forms or even closely allied species are as yet unknown to occur in Cutch, and their apparent absence from the Neocomian deposits of German East Africa and of South America is also noteworthy. Nevertheless, a study of the Uitenhage fauna, undertaken in the light of fuller knowledge, dispels the idea, put forward and emphasised by M. Neumayr, that this fauna proclaims its isolated position by the sharp contrast it shows to the comparable faunas of other regions, and that it may hence be considered to support the theory of an Indo-African land-barrier in early Cretaceous times.[1] Neumayr laid great stress upon the contrast between the fauna of the Neocomian belemnite-beds in the north-west of Madagascar and that of the Uitenhage Series. Even allowing that these faunas are strictly contemporaneous, which has not yet been demonstrated, it is probable that the difference of facies, as recognised by P. Lemoine, would alone suffice to account for the contrast. These belemnite-beds in Madagascar probably represent comparatively deep-water conditions, while the Uitenhage fauna exhibits a shallow-water, littoral character. Since the time when Neumayr wrote, great advances in our knowledge of the occurrence of Cretaceous deposits in Madagascar and on the neighbouring African coast have been made by French geologists, and many facts have now been brought to light which cast doubt upon the existence of an effective barrier to migration between the equatorial and southern waters to the east of the African continent in Cretaceous times. It may reasonably be asserted that the evidence derived from a study of the Neocomian fossils of Cape Colony gives no support to Neumayr's view.

It is well known that Neumayr attached great importance to the occurrence of *Belemnites africanus*, Tate, in the Uitenhage Series in support of his theory of the distribution of cephalopods according to climatic zones.[2] He found this form to belong to a group which, though occurring in the colder waters of the northern hemisphere, is without representative in the warmer equatorial regions. The known distribution of *Holcostephanus* (sensu stricto) might be thought to contribute in like manner and with no less force of suggestion to the evidence in support of the broad principle laid down by Neumayr, but we must hesitate before attaching any such significance to the facts. Our knowledge is as yet very incomplete, and, moreover, a body of evidence relating to the distribution of fossil Cephalopoda has now been accumulated which casts the strongest possible doubts upon the soundness of Neumayr's theory.[1] Facts set forth in the writings of S. Nikitin, F. Kossmat, C. Burckhardt, G. Boehm, and other authors show clearly the necessity of exercising the greatest eaution in estimating the significance of the Uitenhage cephalopods in any general question of distribution. The apparent absence of identical or closely related forms from the Neocomian rocks of German East Africa and of Cutch is very probably owing to our imperfect knowledge of the fossil faunas in these districts; but if this be not the case, the real absence of these cephalopods may possibly have been determined by conditions of a local nature, in manner not unknown among the cephalopod-faunas of various geological horizons within restricted areas in Europe. The same remarks apply to the Neocomian faunas of South America, which have not yet been shown to include any of the South African *Holcostephani* or related forms; but it need scarcely be mentioned that the absence of these Cephalopoda in South America, even though real and not merely apparent, could not be utilized as negative evidence in support of Neumayr's theory. It may be remarked, finally, that the indications for relationship between the bivalve faunas of the Uitenhage Series and the Lower Cretaceous deposits in South America rather tend to strengthen the view, supported by other evidence, that an ancient land surface at that time connected the African and South American continents.

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[1] M. Neumayr, "Die geographische Verbreitung der Juraformation": Denkschr. d. k. Akad. Wiss. Wien, Math.-Nat. Classe, Band L (1885), p. 57. "Erdgeschichte," Band ii, 2nd ed., pp. 259, 261, 295, 296, 529; Leipsic and Vienna, 1895.

[2] M. Neumayr, "Ueber neuere Versteinerungsfunde auf Madagascar": Neues Jahrb. für Min., 1890, Band i, p. 1.

II.—The Lower Ordovician Rocks of Scandinavia, with a Comparison of British and Scandinavian Tremadoc and Arenig Rocks.

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(WITH A MAP, PLATE X.)

(*Concluded from the June Number, p.* 267.)

CONSIDERING now the details of the various districts, we notice that in South Öland the basal beds are shaly and conglomeratic; the higher part is calcareous, and by increase in the proportion of matrix passes into a creamy-white limestone which is wonderfully fossiliferous (O 1 and C). The highest beds are again glauconitic, soft, and shaly. Northward the proportion of calcareous material diminishes, and a band of shale with *Shumardia*, whose lithology and fossil content agree with that of the Ottenby *Ceratopyge* shales below the unconformity, is interstratified with the limestone. This bed is quite inconstant, but in Central Öland another shale band containing *Euloma* occurs low down in the limestone. Beyond Borgholm (O 5 and O 6) all limestone disappears, and only glauconitic shale separates the alternating of *Dictyonema* shale and *Obolus* conglomerate from the *Orthoceras* limestone above. In Central Öland the glauconite shales and Ceratopygekalk attain their maximum thickness of nearly seven feet, but in the north are again reduced to little more than one foot.

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[1] M. Neumayr, "Ueber klimatische Zonen während der Jura- und Kreidezeit": Denkschr. d. k. Akad. Wiss. Wien, Math.-Nat. Classe, Band xlvii (1883), p. 277.

In Vestergötland the detailed succession is particularly variable. Fossils are abundant, especially in the dark pyritous limestone of Hunneberg and Halleberg (W.6), where, however, only the very highest beds of Brögger's 3*a*γ (K 1) seem to be represented. At Kinnekulle (W 2) the succession is much the same as in South Öland, and the creamy limestone is equally fossiliferous. The passage up at both these places takes place through alternations of shales and limestones, and well-preserved Arenig graptolites can be found within a foot of the Ceratopygekalk. In the south of Falbygden (W 4 and W 5) the beds are less than three feet thick, and the limestone and glauconite alternate with thin bands of pale-green shale like the graptolite shales above. At Klefva on Mösseberg the whole division is reduced to a single inch of glauconitic sand or shale, and the *Phyllograptus angustifolius* of the higher series can be obtained within three inches of fine specimens of an early type of *Dictyonema*. Near Sköfde (W 3), in the northern part of this district, a most unusual bank of amorphous blotchy limestone, 20 inches thick and without Korrosionsgruppar, separates the two feet of glauconitic limestone from the shales above. About Berg (E 1) in Östergötland the Glauconiteskiffer is unconsolidated and very like the 'slubber' from the washing of Cambridge Greensand; the green limestone above is like the upper limestone of Kinnekulle, and must represent a very high Ceratopygekalk horizon.

In Nerike the *Ceratopyge* beds have been said to be missing. Shales with *Shumardia* are described by Wiman[1] as occurring some distance above the basal glauconitic marl. The beds here show well-marked Korrosionsgruppar, but are referred by Wiman to the Planilimbatenkalk, so the question must be regarded as still *sub judice*.

Glauconitskiffer have already been mentioned as occurring among the drift of Gefle, where they contain the rich fauna described by Wiman (B 1).

In Dalarne, as seen in the Rettvig–Vicarby railway cutting, the *Obolus Apollinis* conglomerate passes up into rather finer but similarly constituted beds containing much glauconite. These are some three or four feet thick, and are overlain by a six-inch bed of loose glauconite sand and another six inches of green limestone with Korrosionsgruppar and *Symphysurus*, which in my opinion must be the *Ceratopyge* beds of the country. They are succeeded by some seven feet of beds in which limestones with Korrosionsgruppar developed to perfection are interbedded with thin shales which yielded me ill-preserved *Shumardia*, and with them such indications of graptolites that I was compelled to refer them to the Phyllograptusskiffer above. Wiman, however, in his latest paper, G.F.F.S., November, 1906, has shown that a *Ceratopyge* fauna is developed both here and at several other places in Dalarne.

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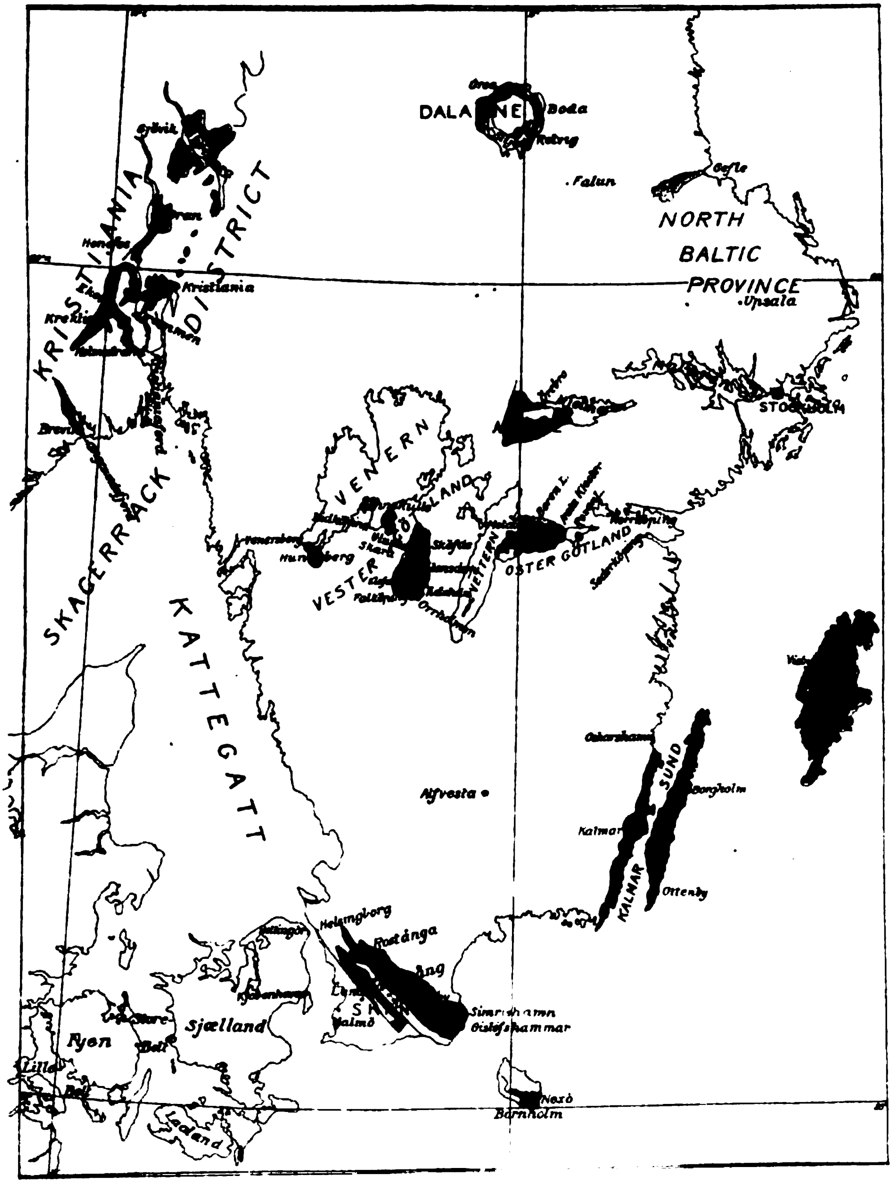
[1] "Ein Shumardiaschiefer bei Lanna," in Nerike. Arkiv för Zoologi Kglsv. Vet. Ak. Stm., 1905.

SKETCH MAP OF SOUTHERN SCANDINAVIA

SHOWING THE DISTRIBUTION OF THE LOWER PALÆOZOIC ROCKS.



C. *The Didymograptus Shales and Orthocerkalk.*

Coming now to deposits which all are agreed to place within the Ordovician system, I can add but little to what has been already published. The graptolitic equivalents of the Arenig or Skiddavian groups of England have been ably discussed by Professor Törnquist in Sweden[1] (C) and by Dr. Lapworth and Miss Elles[2] in this country. The present generation of Swedish geologists (S 1) seems agreed in calling these by Moberg's name, the Didymograptusskiffer (S 5), just as it also unites the graptolitic equivalents of Llandeilian and Caradocian under Törnquist's Dicellograptusskiffer. Graptolitic deposits are, however, not the only type of Ordovician sediments in Scandinavia, and though in Kristiania, Hunneberg, and the greater part of Skåne the lower half of the Arenig is wholly graptolitic, the calcareous deposits of the more eastern provinces must not be forgotten. These limestones have long been known as the Orthocerkalk or *Orthoceras* limestone, but until comparatively recently they have only been classified by their colour, and the fact that they come in at lower and lower horizons as we pass eastward until in Öland they represent the whole of the lower as well as the middle and upper Arenig seems to have been overlooked. Taking these calcareous deposits first, we may note the modern palæontological classification due to Moberg and applied by Hedstrom & Wiman (O 1) to the island of Öland—

Ancistroceraskalk, with a Llandeilo trilobite fauna.
Centauruskalk, with *Illænus centaurus*, *Ogygia dilatata*, etc., and *Didymograptus geminus*.
Platyuruskalk, with *Asaphus platyurus*, *Echinosphærites*, *Lituites*, and many trilobites.
Gigaskalk, with *Megalaspis gigas*.
Upper Asaphuskalk, with a rich but undescribed fauna of small trilobites, *Orthoceras* tolerably common.
The Sphæronite Bed, built up of *Sphæronites pomum*.
Lower Asaphuskalk, with an exceeding rich fauna, including some 24 species of trilobites and a *Phyllograptus*.
Limbatenkalk, with many *Megalaspis limbata*, *Endoceras*, *Orthoceras*, Gasteropods, etc.
Planilimbatenkalk, with *Megalaspis planilimbata*, *Niobe*, *Symphysurus*, and several other genera common to the Ceratopygekalk, into which it passes.

The corresponding classification of the graptolitic deposits due to Törnquist (G) and applied by Törnebohm & Hennig (S 1) to the rocks of Skåne is—

Upper *Didymograptus* shales:
  (*b*) Zone of *Didymograptus geminus*, in which Diprionidian graptolites become abundant;
  (*a*) Zone of *Phyllograptus* cf. *typus*, in which Diprionidian graptolites are very rare;

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[1] "Några anmärkningar om vestra Europas Kambriska och Siluriska Korologi": G.F.F.S., 1889, p. 299.

[2] G. L. Elles: "The Graptolites Fauna of the Skiddaw Slates" (Q.J.G.S., 1898, p. 463); "Some Graptolite Zones in the Arenig Rocks of Wales," 1904, Graptolites, parts 1 and 2 (Pal. Soc.).

Lower *Didymograptus* shales:

(*d*) Zone of *Isograptus gibberulus* (Nich.), with *Asygograptus suecicus* and *Didymograptus hirundo*;

(*c*) Zone of *Phyllograptus densus* (Tqt.) = *P. angustifolius*, with *Didymograptus prænuntius* and many long range species;

(*b*) Zone of *Didymograptus balticus* (Tbg.), with *D. vacillans*, *D. filiformis*, and many other species;

(*a*) Zone of *Tetragraptus phyllograptoides* (Linrs.), with *D. undulatulus*, *D. geometricus*, *D. constrictus*, etc.;

the lowest member of which passes down also continuously into the Ceratopygekalk. Owing to the interstratification of the Orthocerkalk of Scåne between the lower and upper *Didymograptus* shales it is probable that the time value of these various zones is somewhat unequal. According to Hennig (S 1) it is probable that the limestone belongs wholly to the *Gibberulus* zone, and as it would seem that it represents some part of the Limbatenkalk and Lower Asaphuskalk of Öland, it must follow that the lower zones *a*, *b*, and *c* are together the equivalent of the Planilimbatenkalk and lowest Limbatenkalk only.

In Vestergötland we obtain further evidence in the same direction, and, further, are able to follow the easterly thinning of the graptolite beds most beautifully. At Hunneberg only dark graptolitic shales occur beneath the trap, and these to a thickness of about 35 feet represent the two lowest zones with *Tetragraptus phyllograptoides* and *Didymograptus balticus*. At Kinnekulle the shales are greener, but here it is found that the 32 feet measured includes the zone with *Phyllograptus densus* as well as the two lower zones. Here too it can be seen that the *P. densus* zone passes up by alternations into the glauconitic base of the local Limbatenkalk. At Klefva in Western Falbygden only 10 feet of shale overlies the Ceratopygekalk, which is here reduced almost to a line, while at Varnhems, Kloster, and Skultorp, only a little further east, only some 18 inches of shale is seen, and at Sköfde and Ekedalen the recognition of graptolite shales as partings among the limestone seems to be purely theoretical.

In Dalarne the conditions are exactly comparable with those in Vestergötland, but here the replacement of graptolite deposits by limestones follows a north to south rather than a west to east direction, Skattungbyn being comparable with Kinnekulle, while Rättvik is very like Skultorp or Ekedalen. The *Orthoceras* limestone of Boda in this district is interesting in that, like the Leptænakalk of Rättvik, it occurs as the core of a sharp anticline, and has taken on the crystalline structures characteristic of the so-called knoll reefs.

About Kristiania the graptolitic facies is exceedingly well developed (10–80 feet) (K 1), and the calcareous facies comes in at an horizon somewhat higher than at any Swedish locality. Unfortunately the subdivision of these shales, 3*b* of Brögger, has not been worked out, but their highest bed seems to contain the equivalents of the *Didymograptus bifidus* zone of Arenig. Again, the overlying Megalaspiskalk (3*c* α) belongs to the Limbatenkalk, the Expansusskiffer (3*c* γ) being equivalent to the Öland Asaphuskalk, and the 'true' Orthocerkalk (3*c* γ) to the Gigaskalk of the same district. Higher beds in this district become shaly, and with *Ogygia dilatata* and other Llandeilian forms contain *Didymograptus geminus.*

The Boundary between Cambrian and Ordovician Systems.

Summarily, then, we may say that the main stratigraphical features of the Scandinavian Tremadoc and Arenig rocks are inconsiderable thickness and heterogeneity. Their lowest beds, like other members of the Alum Shale Series, preserve a character so uniform that beds hardly more than a foot thick can be recognized in districts five hundred miles apart. The question of the contemporaneity or otherwise of *Dictyonema* shales with parts of the *Ceratopyge* shales remains, but the equivalence of *Dictyonema* shales and *Obolus* conglomerate seems practically certain. The existence of the *Obolus* conglomerate interstratified among *Dictyonema* shales, the break between *Dictyonema* or *Ceratopyge* shales and overlying glauconitic beds, and the numberless lines of contemporary erosion within the latter, all seem to preclude the possibility of any of these beds having had a truly deep-water origin. The wide distribution of individual species of organisms and the comparative thinness of the beds must, on the other hand, most certainly point to a state of great uniformity, and possibly to very open-water conditions. The replacement of the graptolitic Arenig mudstones of the west by the comminuted calcareous organic deposits which form the eastern limestones with their ripple-marks and worm-tracks is further evidence in the same direction, and would seem to show that the eastern districts were at that time areas of considerable tectonic instability. All these stratigraphical considerations have doubtless had their influence in determining for the Swedes, who in such matters are essentially a nation of palæontologists, at what horizon they shall separate the first or Cambrian from the second or Ordovician system, and as the facts have accumulated but slowly, a settlement of the question has been equally gradually evolved. A brief historical summary of the process may perhaps be of interest.

In 1854 Angelin,[1] following Barrande's idea that geological systems are to be defined as definite stages of palæontological evolution, determined that rocks containing a predominance of Olenid trilobites shall in Sweden be termed Cambrian, while those with a corresponding abundance of Asaphids shall belong to the Lower Silurian (Ordovician). In 1869 Linnarsson (W 1) further developed the same idea, and placed the "Regio Ceratopygarum" within the Ordovician. About the same time also Linnarsson began to make use of the graptolites to mark subdivisions within systems already constituted, and in so doing decided to group the *Dictyonema* beds, which at that time were not known to contain trilobites, with the lithologically similar Alum Shales of the Cambrian. In 1881 Brögger (K 1) in Norway, following Kjerulf and Linnarsson, placed the Ceratopygekalk ($3a\,\gamma$) within the Ordovician, and on the evidence that underlying *Ceratopyge* shales ($3a\,\beta$) and beds with *Symphysurus incipiens* ($3a\,a$) both contain Asaphid trilobites, grouped the three together as *Ceratopyge* beds at the base of the Ordovician, and again left the *Dictyonema* beds as the highest member of the Cambrian. In 1890 Moberg,[1] having found the *Dictyonema* shales of Öland passing upwards imperceptibly into *Shumardia* shales with *Ceratopyge* fauna, tried to include these *Ceratopyge* shales along with the *Dictyonema* beds in the Cambrian, and to begin the Ordovician above the lithological break or unconformity at the base of the Glauconiteskiffer. More recently, however, he discovered the bands of Alum Shales with *Ceratopyge* shale fauna interstratified among Ceratopygekalk above the break, and having also in 1898 discovered the Ordovician types of trilobites within the *Dictyonema* shales of Sandby (S 3), has been compelled to abandon that view. In 1900, therefore, he states (O 4) that the *Dictyonema* shales are merely a graptolitic facies of the Ceratopygeskiffer, and as such must with them be included within the Ordovician. This seems, moreover, to be the view now held by all Scandinavian geologists, and if we can agree (1) that there are no true natural boundaries of worldwide application, (2) that geological systems at first broadly suggested may become on further knowledge mere matters of convenience, (3) that the best boundaries are those conventional faunistic lines which are most easy to define and trace, we too shall probably adopt the same. By adopting the *Dictyonema* horizon we give ourselves the opportunity of utilizing to the full the earliest known readily recognizable fossil of pelagic and probably planktonic habit which is known to be preserved among all classes of sediment and in many and distant parts of the world, while by grouping the *Dictyonema* beds with the Ordovician we exclude any considerable developments of graptolites from the Cambrian, and place a horizon which for multitudinous profusion of graptolite individuals is unsurpassed in the system of graptolitic predominance. If, however, we continue to maintain that the old ill-constituted Tremadoc Slates must remain a series either at the top of the Cambrian or base of the Ordovician we become involved in all sorts of difficulties, and are quite unable to ascertain any corresponding boundary either up or down among these well-studied Scandinavian rocks.

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[1] N. P. Angelin: "Palæontologia Scandinavica," 1852, 1854.

Comparison with British Rocks.

Having now stated generally the main features of the Scandinavian Cambro-Ordovician succession, I propose briefly to compare our British rocks with the corresponding members of that succession, and in so doing will consider British rocks also in the order of their superposition.

The newest Welsh rocks comparable with the Alum Shales are the Upper Dolgelly Group[2] or Black Band of the Upper Lingula Flags. These include the zone of *Sphærophthalmus* and *Orthis lenticularis* below and the zone of *Peltura scarabæoides* above. They are not more than ten times as thick as their Scandinavian equivalents, and except for cleavage and absence of calcareous (orsten) material might very well be the hardened representative of beds with Scandinavian lithology. Their faunistic assemblages and succession are also similar, and they preserve their character unchanged along the whole of their known outcrop. The less altered Upper Black Shales of Malvern[1] and the Upper Oldbury Shales of Stockingford[2] are even more Scandinavian in aspect.

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[1] "Om en afdelning inom Olands dictyonemaskiffer såsone motsvarighet till Ceratopygeskiffern in Norge": S.G.U., ser. C, No. 109.

[2] Belt: Geol. Mag., 1867, p. 538.

The Lower Tremadoc Slates[3] or *Niobe* beds,[4] on the other hand, have nothing in common with any Scandinavian rock I have seen. They occupy the stratigraphical position of the *Acerocare* zone of that area, but are not known to contain any of the fossils characteristic of that zone. As discussed in my Arenig paper,[4] the change of lithology at their base is very abrupt, and in the absence of other evidence may, I think, have brought the new Asaphidian fauna into power in Britain before the corresponding displacement of Olenids took place in Scandinavia. It was for this reason that I sought so carefully and laid so much stress upon the discovery of the Asaphidian genera *Niobe*, *Symphysurus*, and *Megalaspis* within the middle and upper parts of the *Acerocare* zone of Sandby, Jerrestadt, and Krekling, and I claim that the existence of these genera at such a horizon puts the stratigraphical correlation of the *Niobe* beds of Britain with the *Acerocare* zone of Scandinavia upon a firm palæontological basis.

The *Obolus* bed mentioned in my discussion of the Shineton Beds of Penmorfa[5] and there grouped with the Lower Tremadoc is very like the *Obolus* sandstone at the base of the *Dictyonema* shales of Östergötland, and is better considered as the basal member of the British *Dictyonema* shales.

The *Dictyonema* shales of Wales have a lithology which is unlike any of the Scandinavian *Dictyonema* rocks. The Tremadoc *Dictyonema*[6] in the Cambridge Sedgwick Museum collection, like my own from Arenig and Dolgelly, have their cells very badly preserved, but on the whole are *Dictyonema* rather than *Dictyograptus*. Their characteristic grouping in radiating colonies of four or six individuals is not well seen in any of the Scandinavian museum specimens, but is strongly suggested in the ill-preserved examples from the lowest *Dictyonema* beds of Krekling and Sandby, and I am of opinion that the Welsh *Dictyonema sociale* represents a very low horizon within the *Dictyonema* series. The Mary Dingle (Shropshire) specimens seem to be of *D. flabelliforme* type, while the Pedwardine and Bronsil shale specimens of Malvern include both low and high types. The Merivale specimens, so far as I know them, are indeterminate.

Of other graptolites we may probably consider the *Clonograptus* or *Bryograptus* of Shineton as equivalent to the lower *Ceratopyge* shales of Norway and *Clonograptus* and *D. norvegicus* beds of Fågelsäng, but of the position of the Barf slabs[7] with *Bryograptus* I do not feel so certain.

The main fossiliferous horizon of British Tremadoc rocks, which includes beds just above and just below the Tai Herion Flags of

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[1] Croom: Q.J.G.S., 1902, p. 39.

[2] Lapworth, "Geology of Birmingham District": Proc. Geol. Assoc., 1898, p. 337.

[3] Ramsay, "Geology of North Wales": Geol. Surv. Memoir, vol. iii.

[4] Fearnsides: Q.J.G.S., 1905.

[5] Rep. Brit. Assoc., 1902, p. 614.

[6] *D. sociale*, Salter: Appendix to Ramsay's "Geology of North Wales" (Geol. Surv. Memoir), vol. iii, p. 331.

[7] Marr: Geol. Mag., 1894, p. 122.

Arenig,[1] the Belswardine locality at Shineton,[2] and the Pen Morfa Post Office beds[3] near Tremadoc, has much in common with the highest Ceratopygeskiffer of Kristiania. The fact that they also yield *Dikellocephalus*, *Cheirurus*, and *Ampyx*-like forms, however, also connects them with the true Ceratopygekalk, and on the whole we may say that they belong to the horizon where *Shumardia* is most abundant.

Of the Upper Tremadoc Slates[4] with *Angelina*, which are known only about the Tremadoc estuary, I can say little, except that, like the *Niobe* beds below, they are totally unlike any Scandinavian series I have seen. As, however, in Wales they overlie the *Shumardia* horizon and have a considerable thickness we must conclude that they too represent some part either of the upper Ceratopygekalk or of the basal portion of the Planilimbatenkalk, but, if so, difference of lithology must account for a very great difference in fauna.

The *Ogygia marginata* and *Peltura punctata* beds of Caermarthenshire[5] I am unable to correlate, but would suggest that the *Ogygia* is probably a *Megalaspis* and is not very like any known Tremadoc or Ceratopygekalk form. The *Neseuretus* beds of Dr. Hicks[6] also have more in common with the Lower Asaphuskalk of Eastern Sweden than with any older bed.

The unconformity which separates Tremadoc from Arenig rocks in North Wales corresponds to some extent to the break which separates *Dictyonema* or *Ceratopyge* shales from the Glauconitic beds and Ceratopygekalk in Eastern and Central Sweden, but occurs, I think, at a higher horizon.

Of reputed Arenig rocks the graptolitic beds have been compared in detail by Miss Elles[7] with the *Didymograptus* shales, and it will here suffice to mention that among these Skiddaw Slates we have the only known British equivalents of the zone of *Tetragraptus phyllograptoides* and a possible continuous passage up from the Tremadoc. In Wales the lowest Arenig horizon is not lower than the upper part of the zone of *Didymograptus balticus*, and in North Wales probably comes within the *Phyllograptus* cf. *densus* zone. The upward succession above this is continuous, and can be checked zone by zone by means of its graptolitic bands. The trilobite beds, like those of the Tremadoc, are not so comparable, and their ashy constitution seems to have had great effect upon the faunas which have little in common with those of the trilobitic *Orthoceras* limestone. The Erwent Limestone[8] of Arenig and the *Neseuretus* beds of South Wales[9] have, however, a general aspect not unlike the Asaphuskalk of Öland.

For more general comparisons I will refer readers to parts i and ii of the new monograph of the Swedish *Ceratopyge* region by Moberg

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[1] Fearnsides: Q.J.G.S., 1905.
[2] Callaway: Q.J.G.S., 1877, p. 652.
[3] Fearnsides: Rep. Brit. Assoc., 1902, p. 614.
[4] Ramsay, "Geology of North Wales" (Geol. Surv. Memoirs), vol. iii.
[5] Crossfield & Skeat: Q.J.G.S., vol. lii (1896), p. 523.
[6] Hicks: Q.J.G.S., p. 39, vol. xxix.
[7] Elles: Geol. Mag., 1904.
[8] Fearnsides: Q.J.G.S., 1905.
[9] Hicks: Q.J.G.S., vol. xxix, p. 39.

Table to show the Distribution of the various Subdivisions of the Arenig and Tremadoc Rocks of Scandinavia.

	Subdivisions based upon the Distribution of the Graptolites.	Kristiania.	Skåne.	Hunneberg.	Kinnekulle.	Falbygden.	South Öland.	North Öland.	Östergötland.	Nerike.	South Dalarne	North Dalarne	Subdivisions based upon a Study of the Trilobites.	
		T	T	...	T	T	T	T	T	T	T	T	Centauruskalk.	Llandeilo.
	Zone of *Didymograptus geminus* ...	G	G	...	...	...	...	...	...	...	...	...		
		T	...	...	T	T	T	T	T	T	T	T	Platyuruskalk.	Arenig.
Arenig	Zone of *Phyllograptus* cf. *typus* ...	G	G	...	...	...	...	...	...	...	...	...		
		T	...	...	T	T	T	T	T	T	T	T	Gigaskalk.	
		T	...	...	T	T	T	T	T	T	T	T	Upper Asaphuskalk.	
		T	T	...	T	T	T	T	T	T	T	T	Lower Asaphuskalk.	
	Zone of *Isograptus gibberulus*	G	G	...	...	...	...	...	...	...	...	...		
	Zone of *Phyllograptus angustifolius* ...	T G	G	...	T G	T G	T	T	T	T	T	T G	Limbatenkalk.	
	Zone of *Didymograptus balticus* ...	G	G	G	G	...	...	...	...	...	G	G		
		...	...	...	...	T a	T	T	T	T	T	T	Planilimbatenkalk.	
	Zone of *Tetragraptus phyllograptoides*	...	G	G	G	...	...	...	...	...	...	...		
Tremadoc		T	...	T	T	T a	T	T	T	? T	T	T	Beds with *Apatocephalus serratus*.	Tremadoc.
		T	T	T	a	a	T	a	a	a	a	a	Beds with *Euloma*.	
	Zone of *Bryograptus Kjerulfi*	T G	T G	a	a	a	T G	T G	? a	? a	? a	a	Beds with *Shumardia*.	
	Zone of *Dictyonema norvegica* ...	G	G	...	...	...	..	...	...	...	...	...		
	Zone of *Clonograptus tenellus*	G	G	? a	...	...	G	G	G	..	...	...		
	Zone of *Dictyograptus flabelliformis* ...	G	T G	G	a	G	G	T G	T G	T G	T G	a	Beds with *Hysterolenus Törnquisti*.	
	Zone of *Dictyonema socialis*	G	G	G	...	...	...	...	G	...	...	...		
		T	T	(T)	a	(T)	(T)	a	a	? a	a	a	Beds with *Acerocare micropygum*.	
		T	T	(T)	a	(T)	(T)	a	a	? a	a	a	Beds with *Parabolina heres*.	
		T	T	(T)	a	(T)	(T)	a	a	? a	a	a	Beds with *Acerocare ecorne*.	
		T	T	T	? a	T	T	T a	T	T	a	a	Zone of *Peltura scarabæoides*.	Cambrian.

Note.—The letter T indicates that the sediments are of shelly or trilobite-bearing type.
The letter G indicates that the sediments contain graptolites of the species indicated.
The letter a indicates that sediments of this age have been proved to be absent.
Parentheses are used to show that the sediments of this age, though probably present, have not yet been distinguished.

and Segerberg so often alluded to above (C), and to the suggestive papers by Brögger on the *Euloma Niobe* fauna,[1] and by Rudemann on the *Dictyonema* shales of New York State.[2]

In conclusion, therefore, I maintain that within the Cambro-Ordovician transition series of Britain and Scandinavia we are able to recognize with certainty the following common horizons—(E) zone of *Isograptus gibberulus* = zone of *Didymograptus hirundo*; (D) zone of *Didymograptus balticus* = base of zone of *Didymograptus extensus*; (C) base of Ceratopygekalk = *Shumardia* beds; (B) base of *Dictyograptus* shales = zone of *Dictyonema sociale*; (A) zone of *Peltura scarabæoides* = zone of *Peltura scarabæoides*; but that no one of these marks any distinctive forward step in the evolution of the trilobites. If trilobites must be retained as the basis of systematic classification, it becomes necessary to begin the Ordovician system somewhere within the *Acerocare* zone of Sweden and at the base of the *Niobe* beds of Britain. This, however, I think would be quite unsatisfactory, and I would urge that instead we follow the lead of the Scandinavian geologists and agree to separate the Cambrian and Ordovician systems in such a way that the *Dictyonema*-bearing beds may be included with the rest of the graptolites within the latter.

III.—NORTH NORFOLK GEOLOGY: THE CHALK AND ITS DISLOCATION.

By Sir HENRY H. HOWORTH, K.C.I.E., F.R.S., F.G.S.

(*Concluded from the June Number, p.* 277.)

MR. CLEMENT REID'S explanation of the broken and contorted condition of the Chalk seems to me quite incomprehensible. Let us analyze the position rather more closely. The champions of ice as the cause of the phenomenon we are discussing appeal to it in two forms—ice-sheets and icebergs. Mr. Reid was, I believe, the originator of the notion that the dislocations of the Norfolk Chalk were due to an ice-sheet, which means an ice-sheet occupying the North Sea.

I should like to quote a sentence or two from the Survey Memoir on the country round Cromer in support of this statement. We are there told that "at Trimingham the chalk has been forced *by glacial action* much above its normal height" (op. cit., p. 3). Again, speaking of the difficulty of ascertaining the entire thickness of the Cretaceous rocks at Trimingham, we read, "Owing to the disturbance from *glacial action* and other causes no very satisfactory dips can be obtained on the coast" (op. cit., p. 5).

On p. 82 of the same memoir Mr. Reid claims that he was the first who, in 1880, suggested that the disturbances in question were caused by the pressure of *the ice-sheet*, which, during the greatest intensity of the cold, probably filled the bed of the North Sea and ploughed up large masses of chalk, driving them laterally into the beds (GEOLOGICAL MAGAZINE, 1880, pp. 55–66). This view was still maintained by Mr. Reid in his Survey Memoir, in which he urged that it was the only one which would fully explain the facts (id., p. 114).

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[1] Nyt Mag fur Naturvidensk. Kristiania, 1896.
[2] New York State Museum, Bull. 69, p. 934, 1903.

The postulate of a North Sea ice-sheet seems to me, as it has always seemed to me, the most stupendous unverified and unverifiable premise that the great adepts in such postulates, the glacialists, have produced. As a physical fact, and even possibility, it is absolutely scouted by every physicist before whom I have put it for criticism, and this includes some of the most distinguished in these realms; and it is astonishing that, in view of this hypothesis traversing very elementary physical laws, it should continue to be put forward by geologists without the smallest attempt to justify its possibility. Note especially Mr. Lamplugh's extraordinary appeals to it in various ways down to the address he lately gave at York.

It is not only the physicists, however, who object to this particular sample of professedly scientific appeals without scientific justification. Pettersen and other Norwegian geologists have conclusively shown that if there was a North Sea ice-sheet it could not have come from Western Norway, since it is perfectly plain from the distribution of the erratics that the Norwegian ice never even reached the string of islands that fringe the Norwegian coast.

Such an ice-sheet, if it existed at all then, could only have been composed of frozen sea-water like that on ponds and lakes, and like that in the palæocrystic sea, which does not move as a glacier moves. Its crystalline structure is entirely different to glacier ice, and it cannot be made to shear. Here, then, are some very elementary reasons why the North Sea ice-sheet of Glacial geologists has been described as a mere outcome of nursery science.

This makes Mr. Reid's appeal to it as an alternative to the Rev. O. Fisher's appeal to the pressure of superincumbent strata a very inconsequent one. Granting, however, the existence of such an ice-sheet (which I am only prepared to grant as having an imaginary existence in Cloudland), how does it serve Mr. Reid's purpose? He seems to think that an ice-sheet could "exert enormous lateral thrust or a sliding pressure from above." How was this to happen? Nothing can be plainer, and I have adduced abundant proofs which have satisfied physicists in more than one of my works that such an ice-sheet could not move *en masse* over a flat or uneven surface for more than a very short distance. No conceivable impulse to cause such a movement as the theory of the North Sea ice-sheet requires is forthcoming which would not crush the ice into slush and dissipate all its energy. Any movement in such ice-sheets must have been molecular and not a movement *en masse*. How is Mr. Reid to secure his lateral pressure or his sliding pressure from above in a mass of ice moving molecularly and in which the molecules moved over each other at a snail's pace? Perhaps some one who understands how the end could be compassed by the suggested means would explain the process before its possibility was so jauntily assumed. Surely this stupendous premise should have been verified.

To me it is an insoluble mystery how such hypotheses can be treated as science at all. Without Mr. Reid's lateral pressure, ice would merely act as a mass of considerable ponderability, pressing on its bed like the very strata press which Mr. O. Fisher appealed to, and which Mr. Reid in his case rejects as impossible, with one considerable element to its disadvantage. While it was possible for Mr. O. Fisher to appeal to differential effects on the subjacent chalk caused by a differential pressure of the superjacent strata he has piled up at different levels, how is it possible to make such an appeal in the case of an ice-sheet whose pressure would necessarily be equable and not differential, for its depth and slope would be uniform if it were made in accordance with what the facts require? How, then, could it produce breakages and dislocations in one place and in another pass over fine layers of sand without disturbing them? These are *a priori* objections, the kind of objections which would occur even to a schoolboy, and which ought to be faced before any such theory is applied to explain concrete facts.

Let us, however, turn to these concrete facts. What are the phenomena which the ice-sheet is supposed to explain? First the meandering and wave-like curves of the chalk in certain places. How is an ice-sheet moving molecularly to bend a solid intractable material like chalk into the sinuous and serpentinous folds we find here? It is not merely the formation of these serpentinous folds that has to be explained, however, but if the ice-sheet came from the sea it is their existence at right angles to the line of march of the postulated monster that has to be explained. It is for those who make the appeal to show its reasonableness. Let us now turn from the contour of the chalk to the mode in which its broken masses occur. The explanation of these masses of transported chalk cannot be separated from that of the loose beds in which they lie as they are exposed in the Norfolk cliffs.

It is not long ago since the phenomena presented by the contorted drifts in the Norfolk cliffs were deliberately and positively ascribed to the action of ice. It was ice which had contorted the drift, it was ice which had detached and redeposited the chalk cakes; ice was everywhere, in fact.

The case looks very different now. The first explanation to go was the biological evidence. Everyone, I believe, now agrees with Mr. Horace Woodward that the so-called glacial shells in the drifts on the Norfolk coast are derivative—that they are the fragmentary and *remanié* contents of the underlying Crag beds, which have been further broken during the portage and then distributed through the superimposed clays and sands, and that there are no glacial shells, properly so called, to be found in Norfolk. This view some of us have maintained for a long time, and the champions of the older view that the shells are true glacial shells, which finds a prominent place in some of the Survey Memoirs on East Anglia, are now reduced to quite a small fraction of their former number.

Secondly, in regard to the contorted sands and clays which form the great mass of the drifts in the Norfolk cliffs, it was a heavy blow to the older and wilder school of glacialists when an American glacialist in whose acumen they greatly trusted and whose leadership they gladly followed, namely Mr. Carvell Lewis, threw over the whole hypothesis in so far as it was directed to explain these East Anglian drifts. He adopted virtually the same views which had long been held about them by other geologists who had the misfortune to be English and to have spent months in their close study instead of making a mere casual and rapid visit in a general survey of the glacial phenomena of the world, quite in the American motor-car style of scientific exploration. He declared quite frankly that he saw nothing in these contorted drifts that had any resemblance to ice action of any kind, and more recent visitors and critics have said the same. These sorted and laminated clays, these sorted and finely laminated sands, tossed and twisted into huge and re-entering curves, have not a single feature in common with the heterogeneous so-called 'muck' (a mixture of clay, sand, and stones) which forms the staple contents of moraines or other ice deposits, and in every cubic inch they bear the unmistakable impress of water action upon them.

It is in the midst of these laminated and twisted and curled clays and sands, all witnessing the action of water in every cubic inch, that we find deposited the cakes and vast polygonal masses of chalk of which I have spoken earlier; and it has been no small proof of the temerity of the glacial prophets that, notwithstanding this patent fact, they should not have shrunk from explaining the detachment of these great masses from their matrix, and their portage to their present surroundings, by means of ice of whose presence the soft matrix in which the chalk masses are embedded does not present a trace, but whose structure and contents are entirely inconsistent with ice action. Many of the more reasonable glacialists admit this fully.

Although they have been stunned and baffled by the overwhelming case against them in regard to the sandy and clayey matrix of the chalk masses, the writers in question still hold on, however, to their *Deus ex machina* in respect to these latter, as if it were possible to attribute the two phenomena, which occur together in an inseparable conjunction, to two entirely different forces acting in an entirely different way and producing entirely different results. The critical test is simple enough.

Granting that at the time when the drifts were deposited the chalk over the greater part of Norfolk was lying horizontally in an unbroken condition at a much lower level than it is now, which I have shown strong reason for concluding, how was an ice-sheet when moving over it molecularly at a snail's pace to break this continuous chalk, and detach from the matrix, the great polygonal masses, the angular fragments, and long ribbons of table-like chalk found in the cliffs? As I have shown at great length elsewhere, modern glaciers do not break up their beds, although they sometimes traverse beds that had been dislocated and broken by other forces long before the glaciers were there. *A fortiori* would the quite hypothetical ice-sheets fail in such work, since their motion was *ex hypothesi* so much more slow and so much more molecular in character than that of icebergs, for they had no slopes to give them impulse and their dynamical energy would virtually be reduced to zero when they were planted on flat or uneven surfaces.

We must remember that, whatever the cause, the broken chalk in most cases shows no signs of crushing or pounding, but only of actual fracture by impact. The masses of chalk are angular, and have raw and unworn edges, the result of forcible tearing and not of crushing, and the chalk with its layers of flint are quite intact from end to end on the chalk cakes. It defies every suggestion available to me how these vast polygons with torn sides and edges (not detached along lines of bedding or of old joints, but right across the solid chalk and the flints it contains) should have resulted from any form of pressure, whether perpendicular or acting laterally. It is even more difficult to understand how the long fragile thin slabs and tables of chalk I call chalk cakes (which are in places still covered by their original covering of Crag), which have irregular edges, and have their lower surfaces with great pieces scooped out as if bitten out by some primæval ogre, could have been detached by any instrument of the character and mode of motion of an ice-sheet.

If the case for causing the breakage and dislocation in question is hopeless when it is an ice-sheet passing directly over the surface of the chalk itself which is postulated, how much more so does it become hopeless when the chalk was covered over and padded with a widespread soft cushion of Crag sands and clays, through which it would be impossible for the requisite dynamical forces to be conveyed at all, much less conveyed without disturbing the lamination of the superincumbent Crag beds?

The breakage and detachment of the chalk masses and chalk cakes from their matrix is not, however, the only puzzle in these cases which seems utterly to baffle all the ingenuity of the orthodox geologists to deal with it. A much greater difficulty exists in explaining the removal, the lifting up to great heights, and the redeposition as we find them in the contorted drifts of these cliffs, of these masses and cakes of chalk.

There is a small school of glacialists who have absolutely forsworn all appeals to elementary physics, who have argued that vast sheets of ice moving very slowly over enormous distances of flat or uneven ground can not only break up their beds but drag up out of their sockets the débris they have formed, like a dentist drags teeth out of our unwilling gums. This tooth-drawing process is a postulate quite after the fashion of glacialist logic. I have examined and criticized it at length in my two last works. What I wish to say here is that even if small angular boulders or polygonal blocks could be thus extracted from the beds on which they lie by a mass of ice which is meanwhile pressing down on them with the weight of many tons to the yard (a process like that of a man lifting into mid-air the chair on which he is sitting), it is surely beyond the reach of the wildest credulity to suppose this could be done with cakes of chalk several hundred yards long, or vast polygonal masses in which chalk quarries have actually been opened. The whole process seems a mechanical nightmare, and it passes human understanding how men have dared to enunciate it as a rational scientific explanation of their difficulties. The mere dragging out of their matrix and detachment of the chalk masses, however, is not all that has to be explained. They have been carried in some cases far from their original site, and in all cases seem to have been carried some distance and redeposited.

This portage and redeposition are assuredly the most insoluble cruces of all to the champions of "omnipotent ice." Granting that the chalk was broken and the pieces lifted from their sockets by some force or other, how could ice take up these vast masses and fragile slabs of chalk, with sand and gravel attached to them, still retaining their original delicate lamination? First, as to the portage. When a glacier carries stones like some of these angular chalk masses (which, be it remembered, are of every shape and size down to the smallest chalk rubble), it can only do so on its back. It is thus the angular erratics of Greenland, Norway, and Switzerland are being carried now. But in all these cases there is no difficulty in accounting for the presence of the blocks on the back of the glacier. They have in all cases been detached from peaks projecting above the ice, and have rolled down upon its back. The present case is very different. There is no question of projecting peaks of chalk detaching portions of themselves, and of these detached pieces rolling down upon the ice, for, as we have seen, when they were formed by the breakage and dislocation of the chalk beds those beds were covered with Crag containing unweathered shells still *in situ*, showing that they were lying at the bottom of the sea. How could an ice-sheet traversing the North Sea (if such a postulate is possible out of a nursery story) transfer from the bottom of that sea to its own back great cakes of chalk still covered with shelly Crag beds, and with their long bodies uncracked and intact, is indeed a puzzle: as great a puzzle as it would be to push a number of eggs through the steel plate of an ironclad without breaking their shells or disintegrating their yolks.

If the ice-sheet did not carry the chalk cakes and other débris on its back, but underneath it, as the advocates of *moraines profondes* argue, the puzzle seems even greater, for it could hardly fail to roll the smaller masses and to round the angles of all. There is virtually no rounding or weathering visible, however, but all are intact. Such portage, again, would scrape off the Crag which covers some of them and would break up its contained shells into powder, for it is clear that if ice can move stones underneath its bed *when travelling over level ground*, which I dispute, and have written a great deal to disprove, it can only have done so by its lower layers dragging along the débris underlying the ice. Such a process, when all movement in the ice was molecular only, and the pace so slow that its rate is not appreciable to the senses, seems, however, quite incredible. Where the motive force was to be derived from to enable a very intangible internal movement of ice particles in an ice-sheet to move along vast masses of chalk many thousands of tons in weight, by dragging them underneath its mass, is incomprehensible to me. That it should have done so without rubbing down the sharp edges of these masses, or in some measure weathering them, and should not have stripped them of their adherent layers of finely laminated and loosely aggregated sands with delicate shells in them, without destroying either laminations or shells, may be pronounced impossible until some glacialist has had the courage and frankness not merely to shoot a wild hypothesis at our heads but to reconcile it with common-sense.

In every way the problem is faced; therefore, whether on *a priori* grounds or inductively, the explanation of the phenomena presented by the dislocation of the Norfolk Chalk by the agency of land ice utterly fails.

Let us now turn to the iceberg theory, which still has some powerful advocates. How icebergs could arise in the North Sea I have never been able to realize, for the Norwegian geologists have virtually shown that they could not have come from Western Norway. Nor do I know, if they could, how the necessary marine currents could have arisen to drive them hither instead of choking the English Channel with them, of which fact, if it ever happened, there ought to be some evidence, and I know of none. The former existence of icebergs in the North Sea is, in fact, a mere unsupported hypothesis and one traversing all probabilities.

Granting the possible existence of icebergs in the North Sea, how are we to explain the dislocated chalk of Norfolk by them?

First, as to the actual bending of the chalk into its serpentinous folds in some places and its breakage in others. How these phenomena are to be traced to iceberg action I have never seen explained. When icebergs are floating they cannot of course reach the bed of the ocean to break or dislocate it. When they come to anchor in shallow water, as they do sometimes, they do not rise and fall with the tide. They are much too heavy to do that, so that bumping by icebergs is not to be thought of. All that they can do in the dynamical way is to rock to and fro; but this process, or even bumping if it were possible on a slight scale, would not roll the chalk *in situ* or the chalk cakes into meandering curves, nor detach these vast polygonal masses as big as churches from a solid matrix many hundreds of feet thick, nor would or could it similarly detach ribbons and cakes of chalk requiring an enormous tearing force; *a fortiori* would it fail to do this when the masses and cakes of chalk were covered with the laminated sands and clays of the Crag and yet not disturb their lines of deposit, and under any circumstances the detached masses would not be unweathered and unworn as we find them. Nor can we in this behalf overlook the very wide extent of country over which these detached chalk masses have occurred, not only very far from the present sea but very far from any probable sea margin in Pleistocene times.

Suppose the breaking of the chalk were explained, the detachment of the great masses from their matrix by tearing them up by the roots out of their sockets seems an utterly impossible process to attribute to icebergs, which under certain conditions may squeeze and press with great force but cannot simulate the tooth-drawing process.

Lastly, how were icebergs to convey the masses when broken and detached? Icebergs cannot gather up material which lies beneath them and transport it. When in water their temperature is too high to enable them to be frozen fast to their unstable anchorage. The only way we can suppose that the vast and most fragile ribbons of combined Chalk and laminated Crag were gathered up by icebergs is either that they squeezed them into their substance by pressing on them, which they could not do without crushing their delicate arrangement, or carried them on their backs; but how is it possible for submerged masses of chalk detached from chalk beds lying at the bottom of the water where the icebergs were floating to be lifted on to the back of any iceberg? A notion that has been gravely propounded, namely, that they rolled down from exposed cliffs, ignores the wide area of inland country far from any coast where they occur, and the utter want of evidence that there were either cliffs or scarps of chalk available from which the masses could have been detached. On the contrary, as we have seen, the most notable of the chalk masses, namely, the chalk cakes, still have the remains of the Crag sea in which they lay attached to them, and we have no evidence whatever that any of the Chalk in Norfolk was above the sea-level when the dislocation took place.

It seems plain, in fact, that ice in any form, either as an ice-sheet or as icebergs, could not have dislocated and distributed the chalk masses as we know them. The hypothesis is at every point inconsistent with the facts.

This virtually means that no known cause acting from above the Chalk was competent to produce the observed effects, and we are necessarily limited to the only alternative cause, namely, some subterranean force of great energy. Such a force is the one whose destructive ruin we so often witness on a limited scale in contemporary earthquakes. As has been shown, earthquakes are marked by actual waves of energy passing through the solid ground, as similar waves pass through the water, and which have the tendency and result when the energy is sufficiently potent to curve the strata through which they pass into a series of anticlinal and synclinal curves, such curves, in fact, as we find in the Chalk of Northern Norfolk and as we find on a much greater scale in the North and South Downs. While this particular phenomenon of the present contour of the Norfolk Chalk seems quite inexplicable by any exercise of force from above, it seems completely explainable by those earth-waves which accompany earthquakes, and to which the most orthodox geologists are quite anxious to appeal when it is a question of explaining the arched, twisted, and torn condition of the crystalline rocks of primitive times. It seems extraordinary that professed Uniformitarians should be so loath to apply the lessons of those early geological times to the Pleistocene age.

The result of such a movement in dense beds of stratified material like chalk must, when the tension was sufficiently great, have caused a vast breakage of the beds, and the broken masses would have the raw edges and torn surfaces we notice in the chalk masses. Not only so, but it seems to me it is the only conceivable way in which the tabular masses of chalk with the stratified material adherent to them could have been detached from the main mass of the chalk. The process would resemble the homely one of the detachment of a concentric layer from an onion by lateral pressure. All pressure or pounding from above must necessarily have smashed up such fragile materials beyond recognition.

So much for the only reasonable explanation of the bending and breaking of the Chalk of Norfolk which, as it seems to me, is available. Let us now pass on to another chapter of the story, namely, that connected with the transport and redisposition of the chalk masses.

As we have seen, the Chalk, when the dislocation and breakage took place, was in all probability lying horizontally at the bottom of the sea, with the Crag shells living upon it or in its covering mud. If this was so, and I cannot see how the case for it can be answered, it is not merely possible or probable but it is absolutely certain that when the dislocation of the chalk took place vast tidal waves would be caused in the superincumbent sea, similar to but on a much greater scale than the monster tidal waves in the Pacific induced by earth-movements such as are known in Java, South America, and Japan. This I have always maintained.

Granting the existence of these vast tidal waves, which great physicists and mathematicians of the first rank like Hopkins and Babbage freely appealed to as *veræ causæ* of great dynamical effects in geology, we at once have an efficient cause for the removal and portage of these vast masses of solid material in almost any form or shape or size, the carrying power of water under these conditions being only limited by the quantity and speed of the liquid in motion.

We have no occasion, therefore, to appeal to transcendental ice ages or ice-sheets or to forms of ice acting contrary to all known forms of ice and supposed to have played a quite impossible jugglery with the laws of matter, but we have at our command a perfectly inductive proof supported at every point by the phenomena to be explained, as well as by the known physical qualities of matter.

The *a priori* postulate here involved, as I have said, is consistent with all the phenomena to be explained, and especially with the conditions under which the chalk masses occur in the Norfolk cliffs. The position of these included masses in the soft beds in which they lie makes it plain that the condition of the sands and clays cannot be treated as a separate phenomenon from that of the great masses and cakes of chalk. These latter lie in laminated sands precisely like in character to the laminated sands which overlie them, and neither the laminations above nor below aredisturbed. When, again, the great masses of chalk are more or less globular or lenticular in shape, the laminations fold round the outlines of the contained masses, showing that the formation of the laminæ was contemporary with the deposition of the chalk masses. Again, the laminations in the clays and the loams are in places continuous with those in the sands, showing that all the contents of the cliffs form one substantial phenomenon.

What is plain beyond measure is that these laminations could not have been made by any substance so rigid as ice and working in the fashion that ice works either in glaciers or icebergs. Everybody admits that, and I do not know anybody, in fact, who would now argue that the stratification and laminæ in question were due to any other cause but water. Inasmuch as the chalk masses and chalk cakes are found at all levels from the foot of the cliffs to their summit and are found deposited under the conditions already described it is clear that water action, and water action alone, can be invoked for the building up of the bed of which the cliffs afford us a sectional view; and if so, it is plain that the masses of chalk and chalk cakes can only have been carried to where they are found and redeposited by water. It is water alone which could have let them gently settle upon finely stratified beds of sand and clay without disturbing the laminations.

IV.—AUSTRALIAN PALÆONTOLOGISTS ON SILURIAN OPHIURIDS.

By F. A. BATHER, M.A., D.Sc., F.G.S.

SOME interesting Ophiurids from the Melbournian rocks of Victoria are described by Mr. F. Chapman in Part viii of his valuable series of articles on "New or little-known Victorian fossils in the National Museum" [Melbourne] (Proc. Roy. Soc. Victoria, n. ser., vol. xix, p. 21; Feb., 1907).

First Mr. Chapman gives a fresh interpretation of the fossil originally described by Dr. J. W. Gregory as *Protaster brisingoides* (GEOL. MAG., Dec. III, Vol. VI, p. 24; 1889), and subsequently made by him the genotype of his new genus *Sturtzura* (Proc. Zool. Soc. London, 1896, p. 1033; 1897). It appears that the fossil described by Dr. Gregory was an imprint in sandstone, and that the true structure is therefore revealed by a wax squeeze, now taken from a similar imprint. Thus, the ridge described by Dr. Gregory turns out to be a canal, and the ambulacral ossicles, instead of being subquadrate, are really boot-shaped, and, in the opinion of Mr. Chapman, closely approach those of *Protaster biforis*, Gregory. Mr. Chapman therefore replaces the species in *Protaster*. The specimens studied by Dr. Gregory are in the British Museum (regd. E. 13000 – E. 13006). Since no holotype was definitely selected by Dr. Gregory, the original of his figures 1 and 2 (regd. E. 13000), is, with his concurrence, hereby selected. Examination of this and some of the other specimens enables me to confirm Mr. Chapman's interpretation in a general way, though not as regards the precise shape of the ossicles. The paratypes of *Protaster brisingoides* (British Museum, E. 13001–6) probably include more than one species.

Dr. Gregory also referred to his genus *Sturtzura* the species *Protaster leptosoma*, Salter. Mr. Chapman gives a diagram of the arm-structure in this species, based on a specimen from Leintwardine, in the National Museum, Melbourne; and in conformity with Dr. Gregory's interpretation, he regards it as of distinct generic type from *Protaster*. He then proceeds to say that since *Protaster brisingoides*, the type of *Sturtzura*, proves after all to be a *Protaster*, therefore "*Sturtzura leptosoma*, Salter sp., must now be regarded as the type form." Mr. Chapman seems for the moment to have forgotten the perfectly definite, and, one had thought, universally accepted rule of nomenclature, according to which the genus must follow its genotype. In other words, *Sturtzura* must become a simple synonym of *Protaster*. The whole object of fixing on a genotype is to avoid the shifting of generic names, and Mr. Chapman's action in taking Salter's species as the type of *Sturtzura* cannot be justified. If *Protaster leptosoma*, Salter, does not belong to *Protaster*, or to any other existing genus, a new name will have to be found for it.

In describing a closely allied species, under the name *Sturtzura leptosomoides*, Mr. Chapman merely quotes the genus as "*Sturtzura*, Gregory, 1897" (which it no longer is), and makes no attempt to give a fresh diagnosis of it. Some doubt may, however, be cast on his interpretation of the two species which he refers to *Sturtzura* (Chapm. *non* Greg.). Thus, he applies the term 'adambulacrals' to certain plates apparently distinct from the ambulacrals, and certainly distinct from the spine-bearing plates. Is it not, however, the case that the spiniferous elements are themselves the adambulacrals, and that the elements to which Mr. Chapman applies the term 'adambulacral' are really processes of the ambulacrals, separated from the ambulacral body by a slight depression? Compare my interpretation of *Bundenbachia*. GEOL. MAG., 1905, p. 164, Pl. VI, Fig. 5). If, however, this interpretation be correct, then the ambulacral ossicles of *Sturtzura leptosoma* and *S. leptosomoides* are really boot-shaped, as in the typical *Protaster*.

Until someone undertakes a comprehensive revision with proper diagnoses, it will save confusion to retain under *Protaster* all the species here mentioned. None of them, not even *P. biforis*, seems to me congeneric with *P. Sedgwicki*, the genotype of *Protaster*. It may well be that a subsequent reviser may separate *P. brisingoides* with *P. biforis* as one genus, and *P. leptosoma* with *P. leptosomoides* as another. In that event, the former genus will of course resume the name *Sturtzura*.

Mr. Chapman also establishes a new genus *Gregoriura*, with genotype *G. Spryi*, for a Protasterid with triangular ambulacrals, of which the three proximal pairs embrace the mouth-frames. A slender bar extending transversely from the outer point of each ambulacral is called an 'adambulacral' by Mr. Chapman; there are also spine-bearing plates. I would suggest that these elements might be interpreted in the same way as those in '*Sturtzura*' are interpreted above. This would not affect the validity of the genus.

It may be worth while to remind English geologists that in 1899 Mr. R. Etheridge, jun. (Rec. Austral. Mus., vol. iii, pp. 128, 129; 17th April), proposed the name *Sturtzaster* to replace the name *Palæocoma*, which Salter had applied to a starfish from Leintwardine. *Palæocoma* had already been used by d'Orbigny in 1849.

May one, without offending several people of importance, express a hope that the future namer of Palæozoic Ophiurids will endeavour to avoid such combinations as "Mr. Spry's Gregory-tail" or "Mr. Stürtz's tail shaped like Mr. Lightbody"? Whether the object aimed at be humour or euphony, few will seriously consider that either is attained.

V.—NOTES ON *METRIORHYNCHUS SUPERCILIOSUS*, DESL.

By E. THURLOW LEEDS.

THE commonest species of the genus *Metriorhynchus* occurring in the Oxford Clay of the Peterborough district is *Metriorhynchus superciliosus* (Desl.). The species found in the above locality has been identified with that of Deslongchamps by the late Mr. J. W. Hulke, F.R.S., in his paper "On the Skeletal Anatomy of the Mesosuchia" (Proc. Zool. Soc. London, November 20th, 1888), and also by Mr. Lydekker in the "Catalogue of Fossil Reptilia and Amphibia," part iv, Suppt., p. 232. Mr. Lydekker, at the time he compiled the Catalogue, brought a cast of part of the skull of *M. superciliosus* to compare with the numerous skulls in the Eyebury Collection.

In view of the fact, therefore, that English palæontologists have identified the common species of Crocodile from Fletton, near Peterborough, with *M. superciliosus*, it seems to have been an entirely superfluous and unwarranted proceeding on the part of Dr. E. Schmidt to have given a new name to the species, viz. *M. Jaekeli*,[1] especially as he has evidently based his species on the one specimen in the Berlin Museum, and at the same time adduces no reasons for his action. Dr. Schmidt is only adding another synonym to a list that is already long enough.

Dr. G. von Arthaber, in the monograph he has lately published,[2] tries to discover the reasons which led Dr. Schmidt to create a new species, and lays great stress on the shape of frontals and præfrontals and the amount and nature of the conjunction of these bones with one another. He denies that it can be *M. superciliosus* on account of "the laterally strongly prominent and anteriorly pointed præfrontals" ("den seitlich stark vorspringenden und gegen vorn spitz zulaufenden Präfrontialien") which this species possesses. If there is one characteristic which could be applied absolutely literally to the Fletton species it is this one, and one which all the skulls of the common *Metriorhynchus* from the Peterborough district show.[3] Dr. von Arthaber says further that there are at least two varieties, *M. Jaekeli* and *M. Moreli*, the former the smaller, the latter the larger type. It would seem that some Continental palæontologists in their desire to discover new species forget to take into consideration such trifles as age or sex in relation to size.

Ten skulls of *M. superciliosus* in the Eyebury Collection show various degrees of length and stoutness, but in all the general proportions are similar, and the sculpture of the frontal bones is identical, though less strongly marked in some than in others.

Mr. Lydekker, in the Catalogue, part iv, Suppl., p. 232, says with regard to *M. superciliosus*: "In the type cranium the præfrontals have only a very short sutural junction with the frontals and a straight inner border, whereas in the type of *M. Blainvillei* of the Kelloway Rock the præfrontals have a long sutural junction with the frontals and a convex inner border. The large series of skulls in the collection of Mr. A. N. Leeds shows, however, such a great variation in these respects that they cannot be regarded as of specific value."

The natural deduction, therefore, is that if these characteristics are unreliable for definitely determining the difference between *M. superciliosus* and *M. Blainvillei*, still greater care must be taken not to create new sub-species of *M. superciliosus*, which shows such variation.

The list of measurements (in millimetres) which I give below is taken from ten skulls practically perfect, except the last one, all in the Eyebury Collection, which I think will bear out my point that while they show for the most part similar proportions, they present here and there curious variations. The explanation of these variations is not due to crushing, as all the skulls, except one, have been compressed in a similar manner, and therefore only slight discrepancies can be ascribed to this cause.

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[1] Zeitschr. Deutsch. Geol. Gesellsch., Bd. lvi (1904), Monatsber., p. 97.

[2] "Beiträge zur Kenntnis der Organisation und der Anpassungserscheinungen des Genus *Metriorhynchus*": Beiträge zur Paläont. und Geol. Österreich-Ungarns und des Orients, Bd. xix (1906), p. 293.

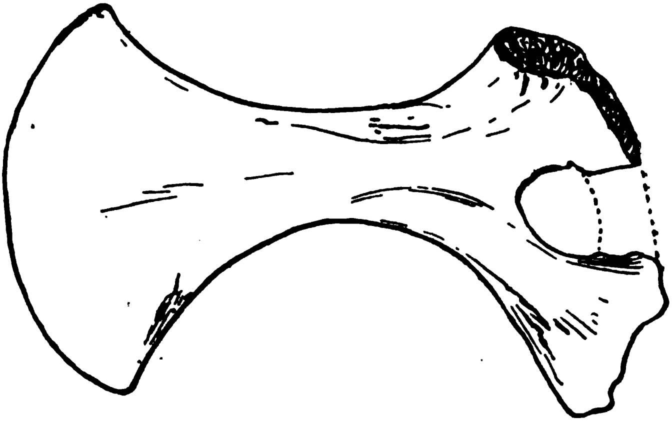
[3] Ibid., p. 288.

No.	Length from snout to occipital condyle.	Breadth præfrontals.	Breadth quadrates	Breadth frontals.	Length præfrontals.	Distance nasal to intermaxilla
6	672	158	190	90	90	72
01	670	151	—	92	88	*c.* 60
163	665	154	185	97	90	80
161	655	141	195	94	90	70
02	637	145	196	88	90	75
162	630	*c.* 146	188	77	90	70
9	580	134	176	87	80	43
8	578	127	175	75	70	*c.* 43
160	578	127	174	71	80	45
Small one	—	98	117	50	50	—
Cast of *M. superciliosus*	—	158	—	100	96	—

No. 162 in the above list is of interest, in that the occipital region of the skull has entirely escaped crushing. It shows a height of 98 mm. to the top of the parietal region. The measurements given by Dr. Schmidt, viz., length 650, and breadth between quadrates 190, agree with the above table. I confess I cannot understand Dr. von Arthaber's measurements. The length of the skull, 603 mm., agrees with the skull as figured on pl. xxii, but he gives as the breadth across the præfrontals 176 mm., whereas the figure certainly does not allow of more than 140 mm., which tallies with the above list. The measurements from the point of the nasals to the intermaxilla are somewhat doubtful, as sometimes the points of the bones are not well preserved.

Pectoral Girdle.—In a paper which he read before the Zoological Society of London in 1888, p. 427 ff., the late Mr. J. W. Hulke included a description of the pectoral girdle of *M. superciliosus*, in which, in spite of a protest made at the time by Mr. A. N. Leeds, he described a portion of a coracoid as that of a scapula. This and the bone which he figures, and correctly so (fig. 2), as a coracoid were taken from two different specimens in the Eyebury Collection, both *M. superciliosus.*

In the latter bone there is a submarginal foramen in the portion of the dorsal end anterior to the glenoid facet; in the former the foramen is represented by a deep notch, which separates the articulating portion from the anterior portion, which latter thus forms a projecting process. The notch commences from the point where the foramen is situated in the perforate variety. An imaginary line drawn across the notch from its two corners will show the similarity in the formation of the two bones thus:—



[illegible]racoid. of *Metriorhynchus superciliosus* (Desl.). Oxford Clay: Fletton, near Peterborough. From the Leeds Collection, Eyebury, near Peterborough.

That these two bones are really coracoids is proved by the fact that Mr. Leeds has never found four bones of this type with one skeleton of *Metriorhynchus*, although he has several times found the entire pectoral girdle. Further, an examination of associated sets of bones of *Metriorhynchus* at Eyebury and in the Natural History Museum, London, shows that in some cases the coracoid has the foramen and in others the notch, whereas the scapula proper is the same in all cases. Nor can a difference of species be proposed as a solution of this dissimilarity, as these two variants of the coracoid are both found with the common form of *Metriorhynchus*, viz. *M. superciliosus*. Consequently the dissimilarity can only be accounted for by a difference in the degree of ossification, or may be ascribed to chance or to sex.

The mistake which Hulke made has unfortunately been perpetuated in Dr. von Arthaber's monograph,[1] and it seems only right that the proofs given above of this grave error should be published.

Dr. von Arthaber does not stop at this point, but proceeds to include the true scapula in a hypothetical and impossible fore-limb of the animal, a mistake which he could not have made had he compared the scapula at all carefully with the metacarpals and phalanges of the hind-limb, or with the scapula of modern Crocodilia.

It may not be out of place here to give a detailed description of the scapula of *M. superciliosus.*

Scapula.—It is an irregularly-shaped, long, and slender bone, the anterior border being longer than the posterior; the proximal end is triangularly rounded, with a flattened inner surface; the shaft is slender and oval in section. The proximal extremity presents two facets, the anterior one being rugose and triangular, corresponding to a similar facet on the coracoid. These two facets form the articulation of the scapula and coracoid. The posterior facet is smooth and somewhat irregular in shape; this facet, together with the rounded, slightly concave facet on the coracoid, forms the glenoid cavity.

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[1] Beiträge z. P. und G. Österreich-Ungarns, 1906, p. 309 ff.

The distal extremity differs from the extremities of the metatarsals, with which the scapula has been confounded, by the absence of a marked ridge, which always bounds their articulating facets. In the scapula the end of the bone is merely the oral shaft flattened out and rounded off.

Fore-limb.—The fore-limb was small, consisting of the humerus, radius and ulna, and some more small bones, of which the bone figured by Dr. von Arthaber[1] in pl. xxv, fig. 2, is probably one, though he has undoubtedly represented it *upside down*. The limb was not a leg for walking, similar to the hind one, but either a degenerate paddle or an incipient one, as Professor E. Fraas[2] declares it to be in the case of *Geosaurus*, in his interesting work on the marine crocodiles (Thalattosuchia) of the Upper Jura.

Dr. von Arthaber's restoration of the fore-limb is certainly erroneous; for in order to construct it he has had to borrow from other parts of the body, viz. the scapula—which he denies to be such—and the first metatarsal, to form the radius and ulna. The whole leg, as he represents it, is entirely out of proportion to the size of the humerus, which would be incapable of carrying such a limb, and further in no way resembles the fore-limb of *Geosaurus*, which he takes as a model on which to complete the parts of *Metriorhynchus* unknown to him.

All Dr. von Arthaber's remarks must be received with extreme caution, not only on account of the undoubted incorrectness of some of his statements, but also because of the absence of careful observation and editing which his work shows. For example, apart from the errors in regard to the pectoral girdle and fore-limb, which I have already pointed out, in pl. xxiii, fig. 8, he figures a left side rib as one belonging to the right side, and in pl. xxv he calls the pubis the ischium and *vice versâ*, while in pl. xxvi he has them correctly named.

I think it will be of interest in connection with this paper to give a short account of the method of occurrence of the bones found in the Oxford Clay of the Peterborough district. A remark of Dr. von Arthaber's[3] leads me to suppose that he thinks the specimens of *Metriorhynchus* are found in such quantities as to make it hard to distinguish one from another, but this is not the case. The area in which they are found consists of brickyards, extending nearly two miles along the Great Northern Railway from Peterborough to London, and the clay is worked to a depth of 35 feet or more. *Metriorhynchus*, like the other animals occurring in this clay, is found at all depths, and at considerable intervals of time in the various pits. Bones that are termed 'associated sets' are found at the same time, and at the same level, in close proximity, if not in position as the carcase of the animal was buried. If there were any doubt as to their belonging to one animal, that doubt is dispersed, because it is a self-evident fact that at some time or other more than one bone of the same kind would have been found together; but as this is not so, and as their colour and size agree, the bones, though scattered over a distance of some yards, must necessarily belong to one and the same animal.

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[1] Beiträge z. P. und G. Österreich Ungarns, 1906.

[2] "Die Meer Crocodilier (Thalattosuchia) des oberen Jura": Paläont., vol. xlix (1902–3).

[3] Beiträge z. P. und G. Österreich-Ungarns, 1906, p. 302.

In conclusion, I wish to say that a large number of the statements I have made are based on the experience which my father, Mr. A. N. Leeds, has gained during a period of over 40 years in which he has collected from the Oxford Clay of Peterborough, and I am deeply indebted to him for the great assistance I have derived from his experience, and for valuable suggestions which he has offered.

REVIEWS.

I.—THE GEOLOGY OF INDIA.

THE IMPERIAL GAZETTEER OF INDIA. New Edition.
Oxford, 1907.

THE first edition of the "Imperial Gazetteer of India" was published in nine volumes in 1881, and a second edition, augmented to fourteen volumes, was issued in 1885–7. The bulk will now be raised from fourteen to twenty-six volumes, including a companion Atlas, and the single volume of the "Indian Empire" has been expanded into four volumes, entitled respectively: I. Descriptive; II. Historical; III, Economic; and IV. Administrative. We propose to notice the chapter on Geology by Mr. T. H. Holland, Director of the Geological Survey of India, in vol. i, p. 50, and the chapter on Mines and Minerals, in vol. iii, p. 128.

1. "INDIAN EMPIRE," Vol. I, pp. 50–103.—GEOLOGY.

Those persons who have paid any attention to this subject are aware that, physically, India consists of three distinct regions, viz., Peninsular India, the Indo-Gangetic Plain, and extra-Peninsular India. A geological map shows this at once, but these features are not equally obvious on an ordinary map. Practically the Indo-Gangetic Plain, with its great alluvial accumulations, separates two regions, which, though markedly distinct in origin and composition, yet afford in each case an interesting geological record, which it is possible to correlate within certain limits. Hence, if we eliminate the deposits of the Indo-Gangetic Plain, the geology of India is a duplicate system, the peninsular beds being without marine fossils, excepting strips along the coast, much resembling Africa south of the Equator in this respect, whilst the extra-peninsular areas in one place or another are able to show an almost complete palæontological column of marine fossils, dating from the earliest Cambrian. It should also be borne in mind that the Peninsula has been a stable area almost from the beginning of geological time, whilst the extra-peninsular region has been one of frequent oscillation culminating in the Himalayan uplift.

Introduction.—Mr. Holland remarks that, in attempting to express these two distinct geological stories in European terminology, we find that our simplest and most easily translated characters are preserved in the marine fossiliferous strata, while it is practically impossible to correlate directly the land and fresh-water formations which are so largely developed on the Peninsula with their equivalent stages in the European standard scale. He also specially points out, by way of illustration, that the flora "which flourished in the great river valleys of the old Gondwāna continent did not make its appearance in Europe until well on in the Mesozoic era, yet, from other evidence, we know that the lowest Coal-measures in India were being formed during Upper Palæozoic times." He further insists upon want of strict contemporaneity in geological formation, and strongly advocates the use of local stratigraphical names.

In the classification of Indian strata there is a trace of a datum-line in the *Neobolus*-beds of the Salt Range, which may be regarded as the equivalents of the *Olenellus*-zone in other Cambrian areas.

To the ages *preceding* the date at which the *Neobolus*-beds were formed he refers—

(*a*) The great mass of crystalline schists which are exposed over half the Peninsula, forming the old floor on which the unaltered sediments were laid down.

(*b*) The great thicknesses of unfossiliferous strata known by such local names as Gwaliors, Cuddapahs, and Vindhyans.

The ages following the Lower Cambrian Period have left their record in two groups—

(*c*) During the Palæozoic era deposits were formed in the extra-peninsular area with fossil remains referable to one or other of the well-known systems of Europe from the Cambrian to the Carboniferous. No records of this era have been preserved in the Peninsula.

(*d*) From Permo-Carboniferous times to the present day we have a double history: a record of life and events on the stable Peninsula, and a series of deposits formed in the adjoining ocean, whose bed was afterwards upheaved to constitute the extra-peninsular parts of India.

Thus Indian rocks fall naturally into *four* great groups: *two* below the *Olenellus* datum-line without fossils, and *two* above the horizon at which the oldest recognizable fossils occur. These four groups are distinguished in the order of priority as (1) the Archæan, (2) Purāna, (3) Dravidian, and (4) Aryan groups.

The Pre-Cambrian History of India may be said to contain three elements, viz., the Archæan era, the great Eparchæan break, and the Purāna era.

The *Archæan rocks*, which occupy so great an extent of peninsular India, are sometimes spoken of as the 'fundamental complex.' This essentially agrees with its development in other countries, and notably in America. "Some of the rocks forming this complex are masses of deep-seated igneous origin: others presumably originated as sandstones, shales, limestones, lava-flows, and other forms of superficial deposit, which became metamorphosed by close-folding, by depression to great depths in the crust, and by further injection of igneous material." He divides the Archæan group in India as follows:—

4. Dhārwārian.

Eruptive unconformity.

3. Granites, anorthosites, charnockite series, norites, etc., of various localities.
2. Schistose and
1. Gneissose rocks.

The Dhārwārs have attracted a special interest on account of the valuable minerals they include: iron-ores in great richness and purity in the Central Provinces and Bellary, copper-ores disseminated at a particular horizon in Singbhūm, and gold in the quartz reefs of Kolār are mentioned.

The Purāna Group.—Upon the weathered surface of the highly folded Dhārwārs and the associated schists and gneisses of the Archæan group enormous thicknesses of sediments were deposited in peninsular India. The break in geological time between these two members of the Pre-Cambrian, or Azoic rocks, appears to the author so enormous as possibly to exceed the entire period of the fossil-bearing rocks, i.e. from the earliest Cambrian to recent times. The Purāna group includes the Cuddapahs of Southern India, amounting to 20,000 feet in thickness with several unconformities. Other examples of this class occur elsewhere in peninsular India, presenting on the whole a lower and an upper series, the latter corresponding generally to the Vindhyans. This is a very interesting formation both topographically, as being conspicuously displayed along the great escarpment of the Vindhyan range, and also lithologically, the rocks being prominently sandstones with subordinate beds of shale and limestone yielding lime and building-stone of considerable economic value. The system is also remarkable for including strata in which diamonds are found, though these, we believe, are part of a bedded sediment, and in no sense indigenous. The author further speculates on the possible existence of representatives of the Purāna group in extra-peninsular areas, and notably in the Himālayas, where unfossiliferous beds, occurring south of the snowy range and crystalline axis, have been referred, without absolute proof, to various members of the regular fossiliferous sequence.

CAMBRIAN AND POST-CAMBRIAN HISTORY OF INDIA.

A. *The Dravidian Era.*

The oldest fossiliferous strata known in India are found in the Salt Range of the Punjab, where beds are exposed with fossils, as previously mentioned, whose nearest relatives occur in the Lower Cambrian. The Salt Range, we may observe, is both an enigma and a godsend to the Indian geologist—an enigma because undoubted Cambrian strata repose on a peculiar marl with beds of rock-salt and gypsum, which may be of Tertiary age; a godsend, because it provides a recognizable base for the palæontological column, but, above all, for its wealth in Permo-Carboniferous fossils, which assist the interpretation of that system in the Himālayas themselves. The geological history of the Salt Range is a blank between the lowest Cambrian and the Permo-Carboniferous, but there are indications here and there of the older Palæozoics in the central Himālayas, where the Vaikritas and the Haimantas are regarded as Upper Cambrian. The Ordovician is represented in the Kumaun area by a coral limestone; while in Spiti this stage is probably not preserved, the lowest of the Silurian beds being red grits and quartzites, with overlying shales and limestones, which contain fossils like *Halysites catenularia*, indicating an Upper Silurian (Gothlandian) age. The Gothlandian beds are overlain by a grey-to-red limestone, which has not yielded fossils sufficiently well-preserved to determine its exact age, though from its position it is probably Devonian (Muth Beds). A Devonian fauna has been proved to exist in Chitral, the evidence being based chiefly on unusually well-preserved Brachiopods, though with a mixture of Corals approximating to Upper Silurian forms, and Devonians have also been recognized in Upper Burma.

Above the Muth quartzite there occur grey limestones with numerous Brachiopoda of Upper Carboniferous age, together with associated deposits containing *Phillipsia*, *Fenestella*, etc., probably of Upper Carboniferous or Permo-Carboniferous age. With these beds, the author says, we approach the close of the Dravidian era in Northern India; for at about this horizon, corresponding to the Upper Carboniferous of England, there is an important break in the deposition, and new conditions are introduced by a widespread conglomerate which forms the base of the marine sediments distinguished as the Aryan group.

B. *The Aryan Era.*

This is the most extensive and important of the four primary divisions adopted by Mr. Holland, being equally well represented by marine formations in the extra-peninsular areas as by fresh-water and terrestrial formations in the peninsular area. Its description occupies three-fifths of Mr. Holland's article, and, as it is not possible on the present occasion to go into particulars, we append the table of the Aryan group as set out on p. 55, once more reminding the reader that the Aryan group represents everything from and including the Permo-Carboniferous up to the present day.

In the extra-peninsular area the changes in physical geography which occurred towards the close of the end of the Carboniferous period are marked by a widespread conglomerate in Spiti and Kumaun. This conglomerate forms the basement bed of a great series of strata which were laid down successively, without a sign of interruption or break, throughout a period corresponding to the whole of the Permian and the succeeding Mesozoic era of Europe. This same boulder-bed, of course, looms largely in the Salt Range, where ice conditions have been claimed for its origin as well as for the analogous Talcher boulder-bed of the Gondwāna system. Above this are various beds, some of which contain a prodigious wealth of Permo-Carboniferous marine fossils. We cannot afford to discuss these, but a few words on the Gondwānas of the Peninsula may not be out of place, since, from an economic point of view, this is the most important of all the Indian formations, and possesses a further interest in the numerous and conflicting interpretations which have been offered as to its true meaning and position in the geological scale; moreover, it is inseparably connected with the bold speculations of Blanford and others as to the existence of a great Mesozoic Indo-African continent.

Table of the Aryan Group.[1]

Marine Formations.	Fresh-water Formations.		Approximate Equivalents.	
Raised beaches; coral banks.	Recent alluvium; Porbandar stone; Desert sand.		Recent.	Post-Tertiary.
Cuddalore sandstones.	Older alluvium of Narbadā and Godāvari.		Pleistocene.	
Makrān Series.	Upper Siwāliks, Irrawaddy Series.		Pliocene.	Tertiary.
Gāj, Yenangyaung, and Prome Series.	Lower Manchnar.		Miocene.	
Nāri.	Kasauli.		Oligocene.	
Kīrthar, Rānīkot, Sabāthu.	... ...		Eocene.	
Cardita Beaumonti Beds. Chikkim Series; Bāgh Beds; Ariyalūr, Trinchinopoly, and Utatūr Beds.	Deccan Trap. Lameta Series.		Cretaceous.	Mesozoic.
Spiti shales; massive limestone of Baluchistān; Umia. Katrol, Chāri, and Patcham Series of Cutch; Hsīpaw Series.	Jubbulpore Series. Rājmahāl and Mahādeva Series.	Gondwana System.	Jurassic.	
Trias of Central Himālayas; Ceratite formations of Salt Range.	Pānchet Series.		Triassic.	
Productus-shales and -limestones, Central Himālayas & Salt Range. Boulder-bed of Salt Range.	Dāmuda Series. Tālcher Boulder-bed.		Permian.	Palæozoic.

The Gondwāna System.—Above the youngest member of the Vindhyan system there is a great gap of unknown width in the geological history of peninsular India, and its next chapter commences with a formation deposited on a land surface, which, it is surmised, had some sort of land connection with Africa and Australia. The basement is known as the Talcher boulder-bed, and a similar boulder-bed is also found in Africa and Australia, all being generally regarded as the result of ice-action, though there does not seem to have been any special glacial fauna associated with such ice-action, as is the case with the great Pleistocene glaciation. Reference has already been made to the analogous boulder-bed in the Salt Range. The author considers that the lowermost beds of the Gondwāna system are fixed by indirect evidence as Upper Carboniferous or Permo-Carboniferous in age, whilst the uppermost stages of this system are associated with marine deposits of Oolitic or possibly Neocomian age. The Gondwāna rocks are preserved as small patches mostly let down by faulting into the great crystalline mass of the Peninsula, whilst isolated patches, including coal-beds, have been involved in the folded extra-peninsular area near Darjeeling and in Northern Assam. Next above the Talchers, in peninsular India, comes the Damuda Series, which contain the most valuable Indian coal-seams; the associated rocks are all sandstones and shales, which sometimes attain a thickness of 10,000 feet. The ironstone shale stage is so called on account of the lenses of clay-ironstone which sometimes occur in sufficient abundance to supply a valuable iron-ore. The Pānchet Series completes the Lower Gondwānas, and is devoid of coal-seams, but has yielded reptilian and amphibian bones to a considerable extent.

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[1] Extracted from vol. i of "The Indian Empire," p. 55.

The three above-named series constitute the lower division of the Gondwāna system, being cut off from the Upper Gondwānas by a marked stratigraphical break, accompanied by a contrast in fossil contents. The plants of the Lower Gondwānas include many equisetaceous forms, while those of the Upper Gondwānas show a prevalence of cycads and conifers; also the species of common genera of ferns, as well as of other orders, are quite distinct in the two divisions. The flora of the Upper Gondwānas is sufficiently abundant, and there are on this horizon great lava-flows, often amygdaloidal like those of the Deccan traps. The predominant flora of the Lower Gondwāna system, in which *Glossopteris* and *Gangamopteris* are prominent genera, has much closer affinities with the Mesozoic plants of Europe than with the plants of the Upper Coal-measures. This fact seemed at first inconsistent with many other evidences pointing to an Upper Palæozoic age for the Lower Gondwānas. "But the explanation offered by the earlier members of the Geological Survey of India, though for many years a stumbling-block to European palæontologists, has received conclusive support in recent times . . . . With a boulder-bed of Permo-Carboniferous age at the base, and a marine intercalation of Jurassic and Neocomian forms near the summit of the Gondwāna system, we have an inferior and superior limit of the time-scale over which to distribute its various series. A considerable fraction of the lowest beds must represent the Permo-Carboniferous, Permian, and Triassic periods; and yet the plants they contain show, when compared with European fossils, a predominating Rhætic and Jurassic facies."

The author further contends for the former existence of an old Indo-African continent, and claims that this supposed land-barrier is rendered probable by a study of the distribution of Jurassic Cephalopods, whilst the Upper Cretaceous fossils demonstrate the existence of such a land-barrier still more completely. "The great revolutions in physical geography which took place towards the end of the Cretaceous and during early Tertiary times resulted in the break up of the old Gondwāna continent, and were followed by the rise of the Himalayan range."

Whether there ever was such a feature in Permo-Mesozoic times as this supposed continent, which is held to have united in biological affinities regions so remote from each other as India, Africa, and

Australia, we have every reason to be thankful that the stable and conservative tendencies of peninsular India have preserved to us fragmentary portions of an old continental area, if only as a counterpoise to the revolutionary forces which built up the extra-peninsular areas from marine deposits, whose fossils are a testimony to their origin and provide us with an index of geological time. W. H. H.

2. "INDIAN EMPIRE," Vol. III, pp. 128–167.—MINES AND MINERALS.

This chapter is also written by Mr. Holland (see preface to vol. iii). "The feature which stands out most prominently in a survey of the mineral industries of India is the fact that practically nothing has been done to develop those minerals which are essential to modern metallurgical and chemical industries, while most striking progress has been made during recent years in opening out deposits from which products are obtained suitable for export, or for consumption in the country by what may be conveniently called direct processes."

Under the head of "Minerals" are tabulated almost everything which the crust of the earth produces, from mineral oils to quicksilver. If the reader is under the impression that India is a great producer in this respect he will be surprised to learn that the value of imported articles of this class in 1903 (£10,500,000) is rather more than double the value of 'minerals' produced (five millions). And yet it seems to have been worse still in days gone by, since there is an increase in production of 46 per cent. in the five years from 1898 to 1903; hence we may hope that the tables are being turned. The imports of iron, steel, and copper figure very largely, whilst the production of iron-ore is ridiculously small. For many years past gold has headed the list in production, and even in 1903 very nearly half the total of the five millions comes from this source.[1] The most satisfactory feature is the steady increase in the output of coal, which in 1903 was valued at rather more than £1,250,000. Salt, saltpetre, and petroleum are next in importance, though still far behind; whilst mica, manganese ore, and jadestone show respectable figures. One could hardly believe that the country which provided the Mogul emperors with their diamonds imported nearly a million pounds worth of "precious stones and pearls, unset" in 1903, while the Burma rubies scarcely reach the figure of £100,000 by way of balancing the account.

The following is the system of classification of the minerals adopted:—

I. *Carbon and its compounds*, including coal, petroleum, amber, and graphite.

II. *Metalliferous minerals*, including ores of gold, silver, tin, copper, zinc, lead, antimony, iron, manganese, chromium, nickel, cobalt, tungsten, titanium, and aluminium.

III. *Materials for construction*, including building and ornamental stone, etc.

IV. *Minerals used in various industries.*

V. *Gem-stones.*

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[1] The total value of gold for 1903 is put down at £2,303,493. In the same year the value of gold produced in West Australia alone is stated to be £8,770,719.

Coal.—During the past twenty years the production of Indian coal has risen from 1,397,818 tons in 1884 to 7,436,386 tons in 1903, the railways being the chief consumers; and this has reduced imported coal to an insignificant figure. Of the total output 95 per cent. was raised from the Gondwāna coalfields of the Peninsula, the remainder being obtained from Tertiary beds in the extra-peninsular area. Bengal is the chief producer, and the most valuable of its coalfields are patches of Gondwāna strata, faulted into the Archæan schists and gneisses, and arranged as a band roughly east to west along the valley of the Dāmuda river. The Rānīganj field, being nearest to Calcutta, still retains its pre-eminence and accounts for 4/7 of the total mined. Next to Rānīganj in importance is the Jherriā field, about 27 miles by 9½ in extent. Workable coal occurs in the upper stage (Rānīganj), but hitherto operations have been confined to the lower stage (Barākar), in which there are eighteen well-defined and mostly valuable seams, varying from 5 to 30 feet in thickness. As in the Rānīganj field, a large amount of damage has been done to the coal by dykes and sheets of a peculiar igneous rock of the nature of a peridotite. Ten years ago this field was not worked, so that the results may be regarded as of good omen for the Indian coal-industry. The Tertiary coals of the outlying areas are of very little consequence, though much was expected at one time from a working on the Dandot plateau of the Salt Range, where, however, the collieries during the last two years have been worked at a loss.

Gold.—This metal, as regards value, has long headed the list of 'minerals' produced in India, though coal is fast catching it up, and there is very little doubt that 'black diamond' will be at the top of the tree in the course of the next few years. Gold is obtained in small quantities by washing in the river-gravels of various parts of India, but the bulk is mined from a rich reef on the Kolār field in the State of Mysore. The deepest workings, now somewhat more than 3,000 feet below the surface, show little diminution in the value or width of the auriferous quartz-vein. The Dhārwār system of foliated schists, forming the 'country rock' of the auriferous quartz in the Kolār field, is represented by bands of similar rocks folded into the gneisses in various parts of the Peninsula, and many of these show traces of ancient workings, but recent operations other than those in Mysore have only yielded poor results.

Iron-ores.—There seems to be a general consensus of opinion that these are abundant and rich, especially in the Peninsula, but the native iron-smelting industry has been practically stamped out by cheap imported iron and steel within range of the railways. The most abundant iron-ores are the minerals magnetite and hæmatite, which occur in numerous places with quartz, making quartz iron-ore schists which are generally members of the Dhārwār and other Archæan schist series. The clay-ironstones of the Coal-measures, no doubt from their proximity to fuel, are also beginning to attract attention.

Other metals.—There has been a considerable quarrying of *manganese-ore* of late, so that India actually takes second place among the manganese-producing countries of the world. In the Nāgpur area the manganese-ore occurs as lenticular masses and bands in the quartzites, schists, and gneisses, and appears to have been formed partly by the alteration of rocks composed of manganese-garnet; the ore is typically a mixture of braunite and psilomelane, though it sometimes consists entirely of braunite—a hard, compact, pure ore, ranging well over 51 per cent. of manganese. The metals chromium, cobalt, nickel, tungsten, titanium, and molybdenum do not call for much remark, and the same might apply to copper, tin, lead, etc., which seem to be very little worked at present. *Aluminium* might arrest our attention for a moment, seeing that bauxite is bound to co-exist with the deposits of laterite so abundant throughout the Peninsula and in Burma. The economic development of these deposits must, however, await facilities for the extraction of the purified alumina in India itself.

Turning now to materials for construction, it must be admitted that India is famous for its building-stone. In the far south various igneous rocks are largely used; in the centre, slates and limestones from the Cuddapah Series and basalt from the Deccan trap flows are quarried. In Central India, etc., the great Vindhyan system provides incomparable sandstones and limestones, while in Bengal, etc., the Gondwāna sandstones are used on or near the coalfields. Among the younger rocks the Nummulitic limestones in the north-west and in Assam are largely quarried, while a foraminiferal stone from Kāthiāwār is extensively used in Bombay and Karāchi. Mr. Holland refers to the famous buildings scattered all over India in proof of the excellence of these materials. The Pathāns and Moghuls utilized both the Vindhyan sandstones of Central India and the beds of marble in Rājputāna for building their magnificent mosques, palaces, and tombs in the cities of Northern India. He refers especially to Fatehpur Sīkri, where a peculiar red and mottled sandstone was used, and this also, if we mistake not, is equally conspicuous in the forts of Agra and Delhi. Moreover, there is the famous Tāj, "built mainly of white Makrāna marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black calcareous shales from the Vindhyans of Chitor, malachite from Jaipur, carnelians and bloodstones from the Deccan trap, and red jasper from the Gwalior Series."

Mining for *mica* is also an industry of some importance; it is a muscovite-mica, which occurs in large pegmatite veins traversing mica-schists in various parts of the Peninsula. Nor should we altogether omit to notice the production of *salt*, which ranks next to gold and coal, though a long way behind, in the Table of Values. Nearly half of this is obtained by evaporation from seawater, and is of less interest to the geologist than rock-salt, deposits of which are confined to the Punjab and the North-West Frontier Province—almost the only instance where extra-peninsular strata take precedence of the Peninsula in the matter of production. Some of this occurs in beds of Tertiary age, as at Kohāt near the frontier, but the bulk is raised from the Mayo mines near Kheura in the Salt Range, where the beds, as already noticed, constitute the *apparent* base on which the lowest fossiliferous beds of India rest. The salt-deposits in this area have an aggregate thickness of 550 feet, of which five seams of very pure material make up 275 feet, while the other half is too earthy and impure to be marketable. There is a difference in the colour of the Kohāt salt and that raised in the Salt Rangè, and this circumstance, so far as it goes, is rather against the theory of the Tertiary age of the famous salt beds near Kheura.

Gem-stones.—This subject, so interesting to the mineralogist, is apparently of little consequence from an economic point of view, since there is no tabular statement of value beyond that given for the rubies of Burma. The mining for gem-stones is a matter of history, especially in the case of the diamond. The localities for this appear to be confined to the Purāna group of rocks, and are three in number. Probably the most famous is that of the Mahānadī valley, in the eastern part of the Peninsula, where stones of great value have been found formerly in the alluvium, but not in the older rocks. In the Vindhyan conglomerates of Central India the diamond occurs as a sort of pebble near Pannā, and the diamond-mining industry is stated to persist still in this area. No results are given, but we can believe that there may be a sort of underground passage for somè of these gems, whose discovery is not recorded on the spot. During the past six years, we are told that the ruby-mining industry in Upper Burma has undergone a favourable change; but, on the whole, it seems to us that even this is disappointing, considering the great expectations at one time formed on the annexation of the country. Other gem-stones, such as sapphire, spinel, beryl, tourmaline, garnet, etc., are noted in small quantities. On the other hand, the amygdaloidal flows of the Deccan trap furnish, either directly or indirectly, a considerable number of agates, whilst the jadeite of Upper Burma has really become an important industry. This jadeite is obtained partly in the form of pebbles and partly by quarrying. In the latter case "the jadeite forms a layer in the dark-green serpentine, against which, on a fresh surface, it stands in striking contrast on account of its light colour. The serpentine is apparently intrusive into Miocene sandstones, and the jadeite must have been separated as a primary segregation from the magma." N.B.—The *jadeite* of China is described as a silicate mainly of alumina and soda, of high specific gravity and great hardness, whilst *jade* is a more basic silicate of magnesia and lime. Thus it is singular that the jadeite of Burma should be associated with such a magnesian rock as serpentine, and its composition may differ from that of China.

W. H. H.

II.—CRYSTALLINE SCHISTS.

DIE KRISTALLINEN SCHIEFER. Von Dr. U. GRUBENMANN, Professor der Mineralogie und Petrographie am Eidgenössischen Polytechnikum und an der Universität Zurich. I. Allgemeiner Teil, mit 7 Textfiguren und 2 Tafeln, 9½" × 6"; pp. vi + 106. Berlin, 1904, M 3·40, bound. II. Specieller Teil, mit 8 Textfiguren und 8 Tafeln; pp. viii + 176. Berlin, 1907, M. 9·60, bound.

THE first of these volumes opens with a historical sketch followed by chapter A (22 pages) on the original material of crystalline schists and its specific characters. The characters of sedimentary and igneous rocks, the formation of the mineral components, the structures and textures and products of differentiation of the latter group are described. Chapter B (24 pages) treats of Metamorphism, under the headings of solvent, temperature, pressure, and factors peculiar to the substance metamorphosed. Chapter C (41 pages) deals with the product of metamorphism in its different forms of development, viz., mineral composition, structure, texture, separation planes, and jointing. Chapter D (7 pages) is devoted to the geological occurrence of crystalline schists, and is followed by a bibliographical list (4 pages).

In chapter B, under the heading of "Pressure," the fact is dwelt on that under high pressure minerals (and rocks) of high specific gravity, and hence small molecular volume, are formed, and numerical instances (partly from Professor F. Becke's papers) of such volume changes are given. In chapter C, under "Mineral Composition," attention is drawn to the zones of metamorphism in accordance with depth proposed by Mr. C. R. Van Hise[1]; but, whereas Van Hise proposes an upper zone of *catamorphism* and a lower one of *anamorphism*, Dr. Grubenmann proposes three zones—an uppermost zone of moderate temperature (heat being liberated), small hydrostatic pressure, great stress, and predominating mechanical pressure effects; a middle zone of higher temperature (heat being liberated or absorbed), greater hydrostatic pressure, very great stress, predominating chemical pressure effects (decrease of molecular volume); a deepest zone of very high temperature (heat being absorbed), very great hydrostatic pressure, weaker stress, predominating chemical pressure effects (recrystallization without change of form). Dr. Grubenmann maintains that certain minerals and certain rocks are characteristic of each zone, and in his second volume he bases his classification on this view.

Under "Structure," in chapter C, many new terms (most of them suggested by Professor Becke) are introduced, e.g., crystalloblastic, idioblasts, xenoblasts, homœoblastic, heteroblastic, granoblastic, lepidoblastic, nematoblastic, pœciloblastic, etc. Professor E. Weinschenk[2] has found fault with these terms, asserting that they are nothing more than a re-coinage of old terms used to describe contact rocks. Professor Becke, reviewing Professor Weinschenk's book,[3] maintains that his object was to sharply contrast the structures common to crystalline schists with the structures of igneous rocks and give appropriate names.

Dr. Grubenmann's first volume is interesting, and the 12 photographic figures of microscopic structures are instructive, but the rocks represented in the figures, their localities, the minerals shown in the sections, and the amount of magnification are not mentioned.

The second volume begins with 9 pages of historical introduction, followed by 9 pages on the principles of the classification adopted by the author. It is primarily chemical and follows the method of

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[1] For full details see his Treatise on Metamorphism (11½"×9"), pp. 1286, with 13 plates and 32 figures. U.S. Geological Survey Monograph, xlvii (1904), reviewed by Mr. A. Harker in *Nature*, lxxiii (1906), p. 450.

[2] "Spezielle Gesteinskunde," Freiburg i/B, 1905, p. 11.

[3] Tschermak's "Mineralogische und Petrographische Mitteilungen," xxv (1906), p. 238.

Dr. A. Osann,[1] the bulk analysis is re-calculated free from water, then the molecular proportions and percentages are calculated, etc. As a result Dr. Grubenmann proposes 12 groups: (1) Alkali felspar gneisses, (2) Silicate of alumina gneisses, (3) Lime soda-felspar gneisses, (4) Eclogites and Amphibolites, (5) Magnesian silicate schists, (6) Jadeite rocks, (7) Chloromelanite rocks, (8) Quartzite rocks, (9) Lime silicate rocks, (10) Marbles, (11) Iron-oxide rocks, (12) Aluminium oxide rocks. Each group is (where possible) divided into three subdivisions in accordance with the three zones of metamorphism proposed in the first volume. The greater part of the volume is occupied by detailed descriptions of the rocks illustrated by 48 photographic figures of microscopical sections, the only fault of which is that the minerals represented in each section are not always indicated.

Although less interesting reading than the first volume the second is likely to be of more practical use. Both volumes have the drawback of being without an index. An author who introduces new terms and leaves one to laboriously search for them handicaps himself. Again, who can tell, *a priori*, that the well-known Saxon granulites are to be looked for in "Die Familie der Biotitarmen Kata-Orthoklasgneisse"? An index would enable one to find them at once.

B. HOBSON.

REPORTS AND PROCEEDINGS.

I.—GEOLOGICAL SOCIETY OF LONDON.

I.—May 1st, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communications were read:—

1. "On the Xerophytic Character of Coal Plants, and a suggested Origin of Coal Beds." By the Rev. Professor George Henslow, M.A., F.L.S., F.G.S.

Of the Palæozoic flora, the *Equisetites*, now represented by the sole genus *Equisetum*, are decidedly hygrophytic, if not hydrophytic. The Ferns, which appear to have much resemblance to certain modern types, especially the *Marattieæ*, seem to have lived under more or less similar conditions to the present; that is, varying from the hygrophytic habit of *Hymenophyllum* to the xerophytic *Ceterach*. The *Cycadofilices*, *Cordaites*, etc., are decidedly xerophytic; and the same is the character of the *Lycopodiales*, represented now by *Lycopodium* and *Selaginella*, and of *Psilotum*, *Salisburia*, and others. In fact, the characteristic feature of the great coal forests was xerophytic, and the vegetation appears to be of an upland type. Illustrations are given from recent and Carboniferous plants, to show the characters of leaf, root, and stem which separate these classes of plants. The position of coal-seams is accounted for by the action of earth-movements in late Carboniferous times: these threw the forest-bearing surface into shallow waves and troughs, which became gradually accentuated, the latter being gradually filled with sediment, upon which, during intervals of rest, new forest growth took place.

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[1] Tschermak's Min. und Pet. Mitteil., xix (1900), p. 351.

2. "Petrological Notes on the Igneous Rocks lying to the South-East of Dartmoor." By Harford John Lowe, F.G.S.

The rocks described are contained in the Newton Abbot district, the region east of the Dart and south of the Teign. They are most nearly related, both geologically and petrologically, to those of South-West Devon, or the Plymouth district described by Worth. The numerous intrusions occurring in the Devonian and Culm rocks have been summarized by Dr. Teall as "for the most part referred to the basic kind known as diabases." The Ashprington rocks are finer grained and lighter in colour than those of the other groups: the Newton Devonian specimens range from light greyish-green to nearly black, and in texture from fine to medium; while the Culm specimens are nearly all of coarser texture, occasionally mottled, and on an average of slightly darker shade. The masses of igneous rock in the district do not display such evidence of extreme dynamic stress as is found among the related rocks farther west. The rocks described from the Devonian volcanic group include tuffs, basalts, and diabases (mostly free from olivine, though there are exceptions), picrite, leucophyre, and kersantite. The Culm volcanic rocks show an absence of the finer-grained basaltic class, as well as some distinct difference in mineralogical constitution of the most nearly allied, indicating subjection to different physical conditions. The rocks include tuffs, diabases, proterobases, epidiorites, camptonites, teschenites, hornblende diabases, mica-lamprophyre, and porphyry.

II.—May 15th, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communication was read:—

"On the Origin of certain Cañon-like Valleys associated with Lake-like Areas of Depression." By Frederic William Harmer, F.G.S., F.R.Met.S.

In glaciated regions, as shown by Professor P. F. Kendall, the invasion of a district by an ice-sheet would tend to obstruct the natural drainage, producing lakes, of which the outflow might take place over the advancing ice, between the ice and the hillsides; or it might escape laterally, in a direction at right angles to the longest diameter of the lake and to the course of the pre-existing stream. Overflow channels would assume a gorge-like character, and would present a comparatively recent appearance. During the Glacial Epoch the North Sea ice appears to have invaded the plain of the Witham and the valleys of the Welland, Nene, and Ouse, overriding also the higher land separating them; the Tees ice-stream moved up the Trent basin to the vicinity of Derby and thence, inosculating with the Derwent glacier, up the Soar Valley towards Leicester and

Rugby; the Irish Sea ice passed into the northern part of the basin of the Lower Severn; ice from the Brecknock Beacons passed towards the Bristol Channel and, combined with Irish Sea ice crossing Pembrokeshire from St. David's Head towards Cardiff, may have caused the accumulation of sedentary ice in the Severn Valley. After considering the case of Lake Pickering and the Malton Gorge as a typical example, the author passes on to Lake Shrewsbury and the gorge at Ironbridge. Pre-Glacial drainage of the Upper Severn and Vyrnwy was probably northwards; when a Glacial lake was first formed over the Cheshire plain it may have drained towards the Trent, possibly by Rudyard and Madely; when these gaps were closed, the lowest outlet seems to have been towards the south, and the Severn Gorge at Ironbridge was cut. The cañon of the Camlad at Chirbury, known as Marrington Dingle, appears to have been caused by outflow from a Church Stoke lake which was driven into the Ordovician ground to the north and east. Lake Trowbridge and the gorges of Clifton and Bradford-on-Avon are next dealt with, the latter being attributed to the overflow of a Glacial lake occupying the Trowbridge plain, and the former to the blocking of the Flax-Bourton valley by ice. The gaps in the Jurassic escarpment at Lincoln and Ancaster are explained as overflows from a lake caused by the damming of the Trent outlet towards the Humber. This gave rise at first to the more northern, and later to the southern gorge. Finally, Lake Oxford and the Goring Gap are dealt with in considerable detail. Certain Drift-filled valleys are regarded as excavated by a river flowing from the south-west—the primæval Thames. The distribution of the Chalky Boulder-clay shows that the advance of the Great Eastern Glacier from the north-east must have arrested drainage flowing towards the Wash, and caused a lake which may possibly have first overflowed through the Newport valley into that of the Stort, or by the Hitchin valley into the Lea, or later into the Colne by the Leighton Buzzard valley. When the ice reached Buckingham, such channels were closed and the overflow must have taken place farther to the south-west, over what are now the Tring, Wendover, and Wycombe Gaps, and eventually by the Goring Gap itself.

Gravels containing Triassic and drifted flint pebbles derived from Glacial deposits may be traced from Goring across the Oxford Plain, at an elevation of between 400 and 500 feet, into the Evenlode Valley, and thence into the basin of the Avon. Their occurrence on the higher slopes of the Goring cañon indicate that the excavation of the latter did not commence until after the arrival of glacially derived detritus in the region in question; the Goring Gap is, therefore, of Glacial age.

The author is unable to reconcile the views here given with those of Professor W. M. Davis on the valley erosion of Central England. Any relation which may have existed between the present drainage system and that of some former period when a peneplain may have extended over the Jurassic and Cretaceous formations alike, and consequent rivers ran out to sea over it, is remote and impossible to trace. With the exception of the Goring gorge, which may be otherwise explained, no connection whatever exists between the drainage systems or the topography of the Cotteswolds and the Chilterns, nor does a vestige remain of the peneplain which, at some unknown height above the present surface, is supposed to have united them. The escarpments form two dip-slopes, to which the streams traversing them are respectively conformable.

The more important rivers of Central England are longitudinal, following the strike of softer rocks along which the predominant erosion has taken place, the transverse drainage being everywhere subsidiary to that of the plains. The excavation of the latter may have taken place at a comparatively early period in a direction not vertical, but inclined more or less with the dip of the softer strata, the formation of the dip-slope and the cutting back of the opposing escarpment being contemporaneous; the erosion of valleys in the dip-slope must have been posterior to this, and could not have preceded it.

III.—June 5th, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

At the Ordinary Meeting on May 15th the President announced that the Council had resolved to award the proceeds of the Daniel Pidgeon Fund for 1907 to Miss Ida L. Slater, B.A. (Dublin), Newnham College, Cambridge, who proposes to investigate the Lower Palæozoic rocks in the neighbourhood of Llandeilo.

The following communications were read:—

1. "A Marine Fauna in the Basement Beds of the Bristol Coalfield." By Herbert Bolton, F.R.S.E., F.G.S.

Isolated and rare fossils have been occasionally discovered in the Bristol Coalfield, but the list of genera and species hitherto recorded is a short one. During the progress of an exploration branch at the Ashton Vale Colliery, fossiliferous shales were traversed in the lowest Coal-measures resting upon the Millstone Grit. A section of the Coal-measures in this part of the coalfield is given, the Gays Seam being the lowest workable seam, and the chief fossiliferous shale is localized at a depth of 84 feet below it. The most striking feature of the fossils is their dwarfed condition, especially among the fish-remains. Fossils found in the spoil banks of other pits indicate that other marine horizons occur in the coalfield. The thickness of the Millstone Grit appears to be about 980 feet. The palæontological description embodies a tabular list of fossils from the marine horizon, which shows a close correspondence with the list drawn up from the marine beds associated with the Gin Coal of North Staffordshire; but it does not appear to be desirable to conclude that the horizons are identical, until further evidence of faunal development has been obtained from the Bristol area. The Brachiopod fauna contains forms identical with, or closely approximating to, species occurring in the *Cyathaxonia*- and *Dibunophyllum*-zones.

The palæontological description contains an account of the different species collected, including notes on *Productus*, *Chonetes*, *Derbya*, and *Orthothetes*, contributed by Dr. A. Vaughan, and new species of *Chonetes*, *Raphistoma*, and *Loxonema*.

2. "Brachiopod Morphology: *Cincta*, *Eudesia*, and the Development of Ribs." By S. S. Buckman, F.G.S.

The test ornament of Brachiopods is found in three main phases—smooth, ribbed, and spinous; and of these three, a costate species is more advanced than a smooth one, and less advanced than a spinose one. There are catagenetic developments, also, in reverse order; but these may, for the present, be neglected. Dall has stated that *Cincta* (*Terebratula numismalis* Group) is a synonym of *Eudesia* (*T. cardium* Group); but, although it would be quite possible for costate forms to be developed from the smooth *Cincta*, yet they would not be costate forms of the *Eudesia* type: in the *Cincta* type the costæ developed would be of the kind which produced opposite carination of both valves, while in *Eudesia* the costæ on the two valves are alternate, the carinæ of one valve being opposed by sulci in the other. This fundamental difference not only prevents the inclusion of *Eudesia* and *Cincta* in one genus, but shows that they belong to entirely different series. The first phase of development dealt with may be called the lenticular stage, which might develop in either of the two directions indicated. The next phase would be the *Cincta* stage, in which the front margin is rounded in youth, truncate in adolescence, incipiently excavate and bilobate in the adult, as the growth-lines of the specimens show. The *Cincta* stage may develop in two directions—out of broad forms the quadrifid stage, out of narrow forms the cornute stage. The next development may be called the quadricarinate or trigonellid stage; and the fourth stage, the multicarinate or *pectunculus* stage. In *Eudesia* there is a highly developed multicarinate stage, but the carinæ are alternate, not opposite. In degree of ribbing it is higher than *Cincta*, and in a way even higher than the *pectunculus* stage; but both the ribbing and the loop forbid connection with *Cincta*. The preceding stage is exemplified by *Ismenia pectunculoides*. A prior stage may be seen in *Megerlia Munieri*; and, as an example of the incipient uniplicate stage, *Terebratula Whitakeri* may be given. Certain emendations in nomenclature appear to be necessitated as a result of this communication; new names are given, and their application defined. A Table is added to show the successive stages of development along the two lines.

CORRESPONDENCE.

CALCAREOUS NODULES.

Sir,—It is interesting to learn, from Dr. Stopes' article on the relation of the Yarra concretionary nodules and the Lancashire and Yorkshire 'coal-balls,' that her recent researches, in conjunction with Mr. Watson, promise to settle the question of the origin of the latter examples. In that paper Dr. Stopes states the supposition that the Yarra calcareous nodules are "more nearly approximate" to the clay-ironstone nodules of the Carboniferous. I was not aware, however, that these contained so large a proportion of woody material as we find in the Yarra nodules, the vegetable remains in the 'siderites' being usually in the form of impressions or carbonaceous films. The proportion of argillaceous matter, moreover, in the nodules from the Yarra, is exceedingly small, whilst the amount of calcareous material is comparatively large. Since I omitted to give the percentages in my paper on the subject, they are here appended. From the context of that paper it will be apparent that the qualifying term 'clay' (only once used in connection with these nodules) was a *lapsus calami*.

The analysis of the nodules from the Yarra estuary is as follows:—Carbonaceous matter = 55 per cent.; calcareous = 41 per cent.; arenaceous and argillaceous = 4 per cent. With regard to the occurrence of quartz-grains, zircons, etc., in the Yarra nodules, it will be seen on consideration that these are accidental constituents of the matrix, due to local conditions, and which would in no respect affect the comparison; whilst the solidity and more completely calcified condition of the English 'coal-balls' could be accounted for by difference in age.

I have examined a large number of the English 'coal-balls,' both microscopically and in hand specimens, and had brought with me to Melbourne a number of characteristic examples, which I have used for comparative purposes. I am not in a position, however, to discuss their relation to the beds in which they occur, since I have not examined them *in situ*; and therefore await Dr. Stopes' detailed description with the greater interest. When these results are published we may perhaps also learn whether the stems of *Calamites* and twigs of *Lepidodendron* have been found actually passing from the nodules into the surrounding deposits. In conclusion, be the theory proved either way, personally speaking it will be equally satisfactory to know that the *modus operandi* of their formation has been successfully elucidated.

F. Chapman.

National Museum, Melbourne.
April 16th, 1907.

AN UNPUBLISHED LETTER OF SIR JOSEPH PRESTWICH ON SUBMERGENCE OF THE BRITISH ISLANDS IN PLEISTOCENE TIMES.

Sir,—At a time when the views of those who, like myself, hold that the partial submergence of the British Isles is the only way in which the existence of beds with marine shells of living species can be truly accounted for, have been partially discredited by the address of the President of Section C at York last year, it may be well to produce the following letter of Sir Joseph Prestwich, upon which I have accidentally lighted while turning over a book of geological memoranda written some years since. In explanation of this letter I may mention that it was written in answer to one from myself, in which I called the attention of the writer to the evidence of submersion as afforded by the existence of the high-level shelly gravels of North Wales and Derbyshire, together with the existence of rolled quartz-pebbles scattered over the Cottswold Hills of Gloucestershire, formed of Jurassic limestones, up to 600 feet above sea-level; a fact corroborated by Professor J. Phillips in his "Geology of Oxford." With this preface I proceed to give Prestwich's letter:—

"*25th July*, 1895.

"MY DEAR HULL,—

Thanks for your letter. I quite agree with you as to the important submergence in Glacial times, which has left such clear evidence on the Cotteswold Hills and Welsh Mountains. It is surprising to me that the ice-ploughing hypothesis could ever be sustained. Some half-century ago it was my good fortune to come across one of the fossiliferous gravels in the hills (1100 feet) between Chesterfield and Buxton. Why the old simple explanation should ever have been pushed on one side in favour of the more fanciful view I cannot understand, unless it be the innate love of change.

"I am,
Very truly yours,
JOSEPH PRESTWICH."

The shelly gravels of Moel Tryfaen, discovered by Trimmer many years since, are well known, having been often described; but those described by Nicholson as occurring at nearly the same level on the Denbighshire Hills (from 1070 to 1170 feet) have not been so generally recognised, and yet are important as indicating the level of submergence over a wide area. The beds occur on the ridge of Millstone Grit of Gloppa, near Oswestry. They are 60 feet in thickness, stratified, and contain numerous marine shells, of which some are living in the Irish Sea and are also found in the Moel Tryfaen beds (Q.J.G.S., vol. xlviii, p. 86).

Before concluding, it may be well in this connection to refer to the important paper by Mr. W. Shone on the "Glacial Deposits of West Cheshire" (Q.J.G.S., vol. xxxiv, p. 383), describing in detail the three divisions of the Drift Series as they are found in Lancashire and Cheshire, and the abundant marine fauna of the Upper Boulder-clay and Middle Sands as they occur near Newton Hollows in West Cheshire, both being underlain by the Lower Boulder-clay. The Upper Boulder-clay is stated to have yielded 57 species and varieties of Mollusca, 2 Polyzoa, 26 Ostracoda, 3 Echini, and the Middle Sands contain 2 species of *Cardium*, also *Tellina baltica* and *Turritella terebra*; from the Lower Boulder Drift shells were absent, but erratic blocks numerous, offering a remarkable contrast to the overlaying marine beds.[1] Those who, with Mr. Lamplugh, refuse to recognise an Interglacial (as well as Upper Glacial) marine stage of the Drift Series, are invited to read Mr. Shone's very instructive paper, which may be considered as descriptive of the Drift deposits as they occur generally throughout the north-west of England.

EDWARD HULL.

14, STANLEY GARDENS, NOTTING HILL, W.
May 20th, 1907.

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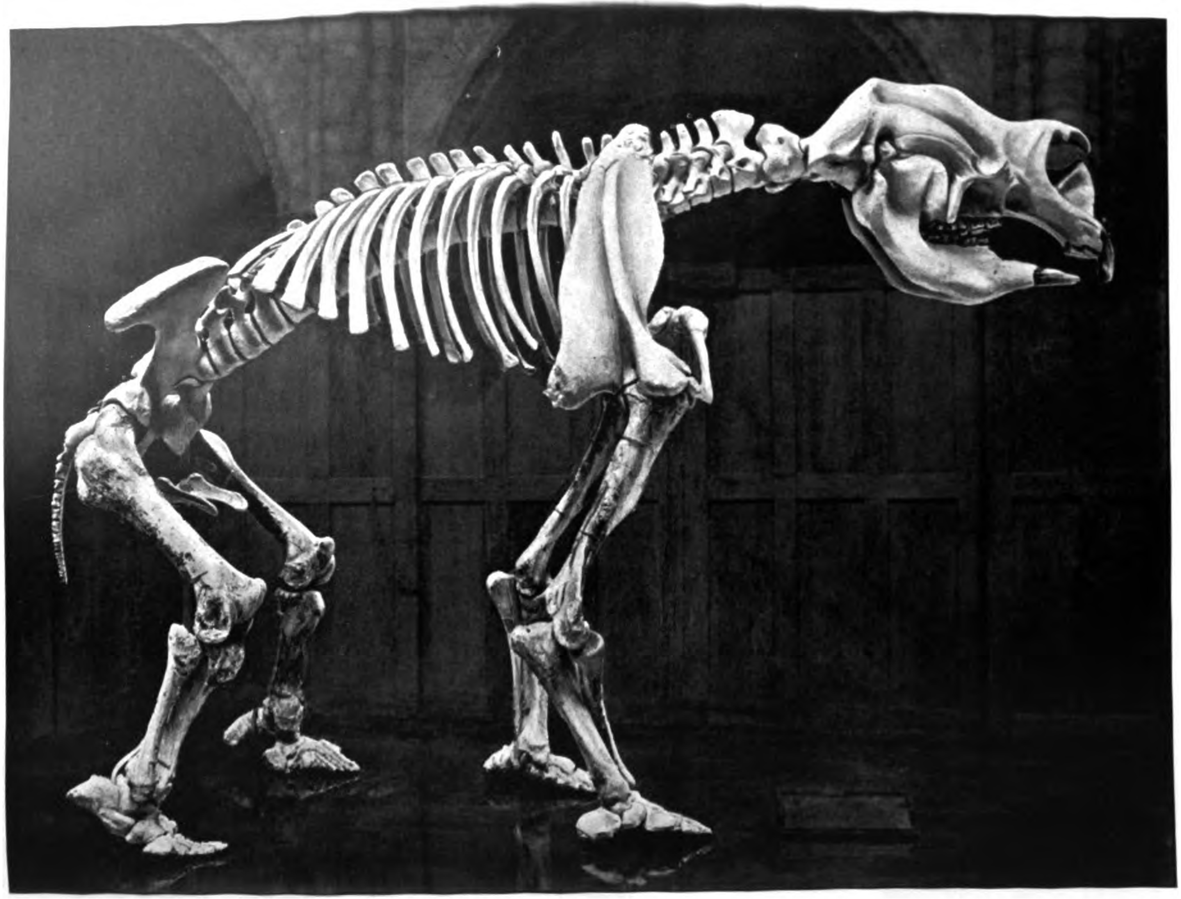
[1] See also Mr. R. D. Darbishire's paper on the shells from the Macclesfield Drift-beds: GEOL. MAG., 1865, pp. 293–299, with a folding-table giving a list of 53 species found there.



Reconstructed skeleton of *Diprotodon australis.*

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. VIII.—AUGUST, 1907.

ORIGINAL ARTICLES.

I.—On a Reconstructed Skeleton of *Diprotodon* in the British Museum (Natural History).

By Arthur Smith Woodward, LL.D., F.R.S.

(PLATE XV.)

FOR many years palæontologists have anxiously awaited the reconstruction of the complete skeleton of *Diprotodon* by Dr. E. C. Stirling, Mr. Zietz, and their colleagues in the South Australian Museum. In 1893, when it was announced that numerous nearly complete skeletons of this gigantic extinct marsupial had been discovered in the arid interior of South Australia,[1] it was hoped that all details of its osteology would soon be known; but the difficulties of excavating and transporting the fragile bones, and the skill and patience needed in preparing them after they reached the Museum in Adelaide, were so considerable as to necessitate long delay in obtaining satisfactory results. At last, however, a mounted reproduction of a skeleton has been completed in plaster, and Dr. Stirling has published three excellent photographs of the specimen in the "Report of the Board of Governors of the Public Library, Museum, and Art Gallery of South Australia for 1905–6," lately received. The Governors of the South Australian Museum have given a copy of this restoration to the University of Cambridge, where it is now mounted in the Museum of Zoology. They have also generously presented to the British Museum a set of actual limb-bones and caudal vertebræ, with sufficient plaster casts to complete the reconstructed skeleton which is shown in Plate XV. As this restoration differs in some respects from that in Adelaide, it appears to need a brief explanation.

The head and the presacral part of the vertebral column in the British Museum specimen are exact copies in plaster of the reconstruction in Adelaide. The skull, unfortunately, is only a restored model, all the original specimens from Lake Callabonna being too much crushed for satisfactory use. The precise shape of the skull of *Diprotodon*, in fact, still remains to be discovered; for a recent careful examination of the specimen from Queensland described by Owen,[1] has proved that the whole of its middle part is a hypothetical restoration in plaster. In the latter specimen all the brain-case is wanting, except the occipital plate; and now that the added plaster has been removed, a correct adjustment of the zygomatic arches shows that the total length of the skull is from four to five inches shorter than it was supposed to be by Owen. The newly-determined length agrees with that of the South Australian model, but in other respects the actual portions of skull preserved differ considerably from the corresponding parts of the model. This model is altogether wider and stouter than Owen's original specimen from Queensland, with a much deeper zygomatic arch. Its mastoid processes are made larger; the occipital plate is higher at the sides, the lambdoidal crest not sloping so much from the apex; and above the foramen magnum there should be a well-marked depression, which was partly filled with plaster in the Queensland specimen when Owen prepared his description. At least, if there is justification for these features of the model in the Callabonna specimens, the South Australian animal is specifically distinct from *Diprotodon australis*. The seven cervical vertebræ agree well with those from Queensland in the British Museum. There are fourteen thoracic and five lumbar vertebræ, all with the neural arches much less elevated than those shown in Owen's original restored drawing of the animal. The centra of the posterior dorsal and lumbar vertebræ are slightly wedge-shaped, and readily form the curve in which they are now mounted.

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[1] E. C. Stirling: Proc. Zool. Soc., 1893, p. 473; also "The Recent Discovery of Fossil Remains at Lake Callabonna, South Australia": *Nature*, vol. L (1894), pp. 184–188, 206–211.

The pelvis and sacrum in the British Museum skeleton are a copy in plaster of a well-preserved specimen from Queensland, with the anterior expansion of each ilium restored from the photograph of a pelvis found in the Wellington Caves, New South Wales (probably now in the Australian Museum, Sydney.) Two Queensland specimens in the British Museum and the original of the photograph just mentioned exhibit only two sacral vertebræ fused with the pelvis, as already described by Owen.[2] We have therefore ventured to regard the sacral vertebræ as normally two in number, and have not reconstructed the additional two vertebræ to conform to the South Australian restoration, which has a sacrum of four vertebræ fused with the pelvis. The caudal vertebræ, actual specimens from Lake Callabonna, are nineteen in number.

In the limbs of the British Museum skeleton, the scapulæ are plaster casts of two specimens from Queensland, while the fore and hind feet of the right side are plaster casts of feet in the South Australian Museum. All the other parts are actual bones carefully selected by Dr. Stirling from his large collection from Lake Callabonna. The humerus and femur are about equal in length, the first being slightly longer, the second slightly shorter than the corresponding bones in Dr. Stirling's restoration. The length of the scapula bears the same relation to that of the humerus as in the latter restoration. The feet exhibit well the diminutive digits, and conform to the admirable description already published by Dr. Stirling and Mr. Zietz.[1] As pointed out by M. Dollo,[2] the reduced and opposable inner digit of the hind foot suggests that the immediate ancestors of *Diprotodon* were arboreal in habit.

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[1] R. Owen, "On the Fossil Mammals of Australia.—Part III: *Diprotodon australis*, Owen": Phil. Trans., 1870, p. 521, pl. xxxv.

[2] Loc. cit., 1870, p. 554, pl. xlvii.

The slight discrepancy in the relative length of the limbs in the two reconstructed skeletons obviously causes a considerable difference in their general proportions and appearance. The curvature of the back and the relatively high forequarters in the British Museum specimen make it approximate more closely in attitude to Owen's original tentative restoration[3] than to the plaster cast as mounted in Adelaide. In both cases the limb-bones seem to have been selected from several individuals, and Dr. Stirling and Mr. Zietz have not yet published their measurements of the complete skeletons as they lay on the ground before removal.[4] The final decision as to the exact proportions of *Diprotodon* must depend on these and other measurements of associated bones, for it is evident that individuals vary in size. While expressing our grateful appreciation of the valuable contributions which Dr. Stirling and Mr. Zietz have already made to our knowledge of this remarkable extinct Australian quadruped, we therefore venture to hope that their memoir on the whole skeleton will now soon be ready for publication.

The original photograph of the skeleton of *Diprotodon*, used in preparing Plate XV, was taken by Sir J. Benjamin Stone, M.P., F.G.S., on the 14th June last, in the Hall of the British Museum of Natural History, Cromwell Road, and by his kind permission is here reproduced for the first time.

II.—The Cretaceous Rocks of Natal and Zululand and their Cephalopod Fauna.

By G. C. Crick, A.R.S.M., F.G.S., of the British Museum (Natural History).

(WITH A PAGE MAP.)

In the "Third and Final Report of the Geological Survey of Natal and Zululand" that has just been published the Cretaceous rocks and their fauna receive considerable attention; Mr. William Anderson, F.G.S., the Government Geologist, gives an excellent summary (pp. 47–64) of all the information he had been able to obtain respecting the Cretaceous rocks of Natal and Zululand, and there are two contributions on the fauna of some Cretaceous deposits in Zululand, one by Mr. R. Etheridge and the other by the present writer. Before referring particularly to the Cephalopod fauna of the Cretaceous rocks of Natal and Zululand it may be of interest to give a brief sketch of the distribution of these rocks as recorded by Mr. Anderson.

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[1] E. C. Stirling & A. H. C. Zietz, "Description of the Manus and Pes of *Diprotodon australis*, Owen": Mem. Roy. Soc. S. Australia, vol. i (1899), pp. 1–40, pls. i–xviii. See also Geol. Mag., 1900, p. 28.

[2] L. Dollo, "Le Pied du *Diprotodon* et l'Origine Arboricole des Marsupiaux": Bull. Sci. France et Belg., vol. xxxiii (1900), pp. 278–283.

[3] Loc. cit., 1870, pl. L.

[4] See the interesting photograph in Mem. Roy. Soc. S. Australia, vol. i, pl. A, fig. 2.

More than fifty years ago the presence of rocks of Cretaceous age was recorded on the coast of Pondoland,[1] to the south of Natal, and in geological literature these are not infrequently referred to as Cretaceous rocks of Natal, but the first record of the occurrence of Cretaceous deposits in Natal and Zululand was made in 1871 by Mr. C. L. Griesbach in his paper "On the Geology of Natal in South Africa," who, when describing more especially the Cretaceous deposits of Pondoland, records the existence in Natal of Cretaceous outcrops "on the Impenyati River and at some of the more southern rivulets which run into the sea between the boundary of Natal and the St. John's River (Umzimvooboo)." "The same," he goes on to say, "are also recognised in the bed of a small stream, running into the St. Lucia Bay, in the Zulu country." Shortly afterwards Mr. St. V. W. Erskine recorded the occurrence all the way up from St. Lucia Bay to the Zambesi River of limestones and arenaceous beds; these Mr. Anderson considers to be of Upper Cretaceous age, excepting perhaps some deposits in isolated positions that are probably of Tertiary age.

In Natal proper there are only two localities in which Cretaceous rocks are known to occur. The more southerly of these is on the south-east coast, and extends between high and low water marks northwards from the mouth of the Umpenyati River (about nine or ten miles from the Umtamvuna River, which forms the southern boundary of Natal) to within half a mile of the mouth of the Umhlengeni River, a distance of about a mile and a half. The other locality is at Durban, between 80 and 90 miles further north, where the rocks were met with in a boring at the Bluff.

In Zululand the most southerly point at which Cretaceous rocks are known to occur is on the north side of the Umhlatuzi Lagoon, close to the coast, where they have been found in borings, but Mr. Anderson thinks it is probable that they are also present under the most superficial deposits nearly as far south as the Umlalaaz River, which is some twenty miles farther south, i.e. about five or six miles south of Port Durnford, although no deposits of this age have actually been seen on the coast between the Umhlatuzi Lagoon and Durban in Natal, a distance of about one hundred miles.

Of the surface outcrops of the Cretaceous rocks in Zululand the most southerly is at Umkwelane Hill, near Lake Isitesa, on the south side of the Umfolosi River. It is entirely confined to the hill. This deposit, of which the fauna has been described by Mr. R. Etheridge in the "Second Report of the Geological Survey of Natal and Zululand," 1904, is some 20 miles north of the Umhlatuzi Lagoon and about 15 miles from the coast. According to Mr. Anderson the limestone in the two localities is almost identical petrologically, whilst some of the fossils obtained from the bores at the Umhlatuzi Lagoon were identifiable with some of those occurring at the Umkwelane Hill. At the common exit of the Umfolosi River and the drainage of St. Lucia Lake into the sea at St. Lucia Bay, there are calcareous sandstones which hitherto have proved unfossiliferous; these, and similar rocks occurring further to the north at Cape Vidal, Mr. Anderson is inclined to think will prove to be of Tertiary age. At many points round the edges of St. Lucia Lake and False Bay, Mr. Anderson observed low outcrops of horizontally bedded strata, consisting chiefly of calcareous marls and sandstones. The few fragmentary fossils obtained from these Mr. Etheridge was inclined to refer rather to the Tertiary than to the Cretaceous system. Near the northern end of False Bay the western boundary of the littoral is formed by the Rhyolite of the Lebombo Range, which extends thence northward past the Portuguese border; between False Bay and the western boundary of the littoral there are several Cretaceous outcrops which have yielded characteristic Cretaceous fossils.

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[1] R. J. Garden, "Notice of some Cretaceous Rocks near Natal, South Africa": Quart. Journ. Geol. Soc., vol. xi (1855), pp. 453–454. W. H. Baily, "Descriptions of some Cretaceous Fossils from South Africa, collected by Captain Garden of the 45th Regiment": ibid., vol. xi (1855), pp. 454–465, pls. xi, xii, xiii.

As it is principally with the Cephalopod fauna of these several outcrops that the present communication deals, they may be best described in Mr. Anderson's own words.

"The Manuan Creek,[1] which joins the Umsinene River before its entrance into False Bay, has three tributaries, over each of which the northern wagon-track passes. Near each of the three crossings outcrops of Cretaceous rocks occur containing fossils. The fossils from the outcrops at the most southerly tributary are described by Mr. R. Etheridge as Part II of the 'Cretaceous Fossils of Natal,' in the present Report of the Geological Survey (p. 67), under the title of the 'Umsinene River Deposit.' This name does not describe accurately the position of the deposit from which the fossils that are described came, but owing to the fact that there are four fossiliferous deposits all in a small portion of the Manuan Creek basin, the name 'Umsinene Deposit' refers to the deposit occurring immediately to the north of the crossing of the most southerly tributary of the Manuan Creek. The others are at the crossing of the middle and the northern tributary, to the east of Crossly's store, while the fourth locality is near, but to the west of, the junction of the Manuan Creek with the Umsinene River.

"The outcrop of the 'Umsinene deposit' is of limited extent and is exposed chiefly in the bed of the southernmost tributary of the Manuan Creek, and on the rising ground to the north of it, and it again appears where the wagon-track crosses the next spruit to the north. The rock is a calcareous, argillaceous, fine-grained sandstone of a brownish colour, with fossils scattered sparingly through it . . . .

"The next deposit occurs on the middle tributary of the Manuan Creek to the north. Where the wagon-track crosses this creek the rock is Rhyolite, which persists right to the source of the creek. Below the crossing the right-hand bank is entirely of Rhyolite, while on the left-hand bank a small outcrop of fossiliferous Cretaceous rocks occurs."

"The fossils in this deposit," says Mr. Anderson, "are described by Mr. G. C. Crick . . . . in this Report under the title of 'The South Manuan Creek Deposit.'"

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[1] This name is not given in any of the maps accompanying Mr. Anderson's reports, and has therefore been omitted in the map which is reproduced herewith. It appears to be the stream, flowing from the north, which joins the Umsinene River just before its entrance into False Bay.

"At intervals," Mr. Anderson continues, "Cretaceous beds crop out in the bed of the northern tributary of the Manuan Creek as far west as the point where the Mkuzi[1] River track crosses the creek, at the foot of the hill to the east of Crossly's store . . . . The fossils from this deposit have not yet been described."

"The other fossiliferous Cretaceous deposits," writes Mr. Anderson, "which I have been able to visit and make collections from are situated near the junction of the Manuan and the Umsinene Rivers. The exposure shows a thicker series of beds than in any other locality from which I have collected. There are from 70 to 100 feet of strata exposed, chiefly calcareous sandy shales and sandstones, the whole being capped by a very hard calcareous sandstone full of broken shells. The beds are exposed almost continuously where the bank is precipitous. They are exceedingly prolific in fossils, chiefly Mollusca, Cephalopoda, and Gasteropoda. The Cephalopoda are extremely abundant, and range in size from forms of half an inch to over a yard in diameter. The fossils weather from the shales in a perfect condition, but from long exposure on the surface to the atmosphere, rains, and bush fires, they are largely composed of casts. Some good specimens, however, were obtained. These are described by Mr. G. C. Crick, of the British Museum, in this Report, under the title of the 'North End of False Bay Deposit.'"

According to Mr. Anderson there are many other localities in the neighbourhood of False Bay where the Cretaceous rocks are exposed, but he had not been able to make collections from them. The most northerly point from which he had obtained fossils was to the east of Crossly's store, near the southern end of the Lebombo Range, but he knows of other outcrops of fossiliferous rocks still further north.

Having given this brief sketch of the distribution of the Cretaceous rocks of Natal and Zululand, attention may now be directed to the Cephalopod fauna of these deposits.

It may first be mentioned that the fauna of the Cretaceous rocks of Pondoland (known also as the Umtamfuna or Umzamba Beds), that was first described by Baily in 1855, has quite recently been the subject of a memoir, in the Annals of the South African Museum (vol. iv, pt. 7, 1906), by Mr. H. Woods, who concludes that the whole of these beds are of Campanian (Upper Senonian) age.

Of the two localities in Natal proper at which Cretaceous deposits are known to be present, the beds at the one which occurs on the coast between high and low water marks, between the mouth of the Umpenyati River and the mouth of the Umhlengeni River, agree, according to Mr. Anderson, both petrologically and palæontologically with the beds on the coast of Pondoland to the south. As Mr. Anderson points out, the lower portion of the series is much more fossiliferous than the upper portion, though it is not possible to divide the series into recognisable subdivisions. From the list of the Cephalopoda given by Mr. Anderson (Third Report, pp. 50–51), there can be no doubt about the identification of these strata with the Umtamvuna or Umzamba Beds.[1] At the mouth of the Boboi River, between the Umtamvuna and Umpenyati Rivers, there is a small outcrop of horizontal unfossiliferous sedimentary rocks that Mr. Anderson thinks is probably a small outlier of the same series of rocks.

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[1] Spelt 'Umkusi' on the map.

In the boring at the Bluff, Durban, only fragmentary fossils were obtained; no Cephalopods are quoted. In his work on the "Pseudoceratites of the Cretaceous" (Mon. U.S. Geol. Surv., vol. xliv, 1903), Professor Hyatt described and figured (p. 86, pl. xi, figs. 2–6) as *Eulophoceras natalense*, gen. et sp. nov., a single specimen, the locality of which he gave as Port Natal, South Africa. Mr. Anderson doubts the locality given by Hyatt, and says (p. 50): "As the presence of Cretaceous rocks at Port Natal has only recently been made known, and as no outcrops of them occur on the present land surface, it is unlikely to have been thrown up from the possible outcrop on the sea-floor, and I think it is more than probable that the actual locality from which it came was not Port Natal, but probably it was a specimen which had been brought to the Port, either from the Upper Cretaceous deposits at the mouth of the Umpenyati River, on the south-east coast of Natal, or from the Cretaceous deposits on the coast of Pondoland." This opinion is strengthened by the occurrence of the same genus and possibly the same species among the fossils described by Mr. Woods from Pondoland.

In Zululand the most southerly outcrop of Cretaceous rocks from which fossils have been obtained is at Umkwelane Hill, near Lake Isitesa, south of the Umfolosi River. The fossils, which were described by Mr. R. Etheridge in the "Second Report of the Geological Survey of Natal and Zululand," 1904, included a few Cephalopods, viz., two new species of *Placenticeras*, an undetermined species doubtfully referred to the genus *Creniceras*, a fragment of *Hamites*, and a piece of *Baculites*. Comparing the whole fauna with that of the Umtamvuna (or Umzamba) Beds in Pondoland, Mr. Etheridge says (Second Report, 1904, p. 93): "*Puzosia Gardeni*, Baily, sp., has not been observed in the present collection, nor any of the Ammonites mentioned as occurring in Griesbach's stratum *c*, nor *Teredo*-bored wood as in *e* of the same author. The fauna of the Umkwelane Hill Deposit consists, with few exceptions, of bivalves and univalves, like that of Griesbach's stratum *b*, and some of the species are identical with those met with in the latter. There appears to be a close connection between the fossils of the two beds; possibly they may be actually on the same horizon." Mr. Woods considers the Umkwelane Hill Deposit to be of the same age as the Cretaceous rocks of Pondoland, and this opinion is strengthened by the occurrence at Umkwelane Hill of an ammonite which the present writer refers (Third Report, 1907, p. 228, pl. xv, figs. 9, 9*a*) to the genus *Mortoniceras*, and regards as being related to *Mortoniceras Soutoni* and *M. Stangeri* from the Cretaceous rocks of Pondoland.

Although this is the most southerly outcrop of the Cretaceous beds in Zululand, they have been met with some 20 miles further south, in bores which were sunk to the north of the Umhlatuzi Lagoon close to the mouth of the Umhlatuzi River, as an arenaceous limestone full of fossils, which, according to Mr. Anderson, were identifiable with some of those occurring in the limestone at Umkwelane Hill.

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[1] The present writer has also recognized (Third Report, 1907, p. 250) from the Umpenyati strata an example of *Schlœnbachia umbulazi*, a species originally described from the Pondoland deposits.

Most of the outcrops of Cretaceous rocks in Zululand, from which Mr. Anderson collected fossils, are in the neighbourhood of the north end of False Bay and St. Lucia Lake, some 40 miles north of Umkwelane Hill. The fossils from several of these outcrops have been described in the "Third and Final Report," which has just been issued.

Some of these fossils are described by Mr. R. Etheridge under the title of the "Umsinene River Deposit"; whilst the present writer has described "The Cephalopoda from the North End of False Bay, Zululand," and "The Cephalopoda from the Tributaries of the Manuan Creek, Zululand."

As already stated, the Manuan Creek, which joins the Umsinene River before its entrance into False Bay, has three tributaries, over each of which the wagon-track passes. It was, Mr. Anderson states, from the deposit occurring immediately to the north of the crossing of the most southerly tributary[1] of the Manuan Creek that the fossils described by Mr. Etheridge under the title of the "Umsinene River Deposit" were obtained. Referring to this fauna Mr. Etheridge says: "Only one species can be said to be actually identical with the Umkwelane Hill fauna, viz., *Alaria* (?) *Bailyi*, Eth. fil., but as the general facies of the Umsinene fossils resembles that of the Umkwelane Hill bed, I am induced to regard them simply as horizons in one and the same geological series." Mr. Etheridge goes on to say: "If my determinations of these very fragmentary fossils are correct, we find in the Umsinene bed four Uitenhage forms" . . . . and then, referring to the Cephalopoda, which include only a few forms, viz., *Douvilleiceras* (?) *nodosum*, n.sp., *Douvilleiceras* sp., *Desmoceras* sp., and *Hamites* sp., remarks that "as in the case of the Umkwelane Hill fauna there is an entire absence of those species recorded from his Umtafuna fauna by Griesbach."

Of the Cephalopod faunas described by the present writer in the Report, that from the deposit at the north end of False Bay, and near the junction of the Manuan and Umsinene Rivers, where from 70 to 100 feet of strata are exposed, is a particularly rich one, the forms ranging in size, according to Mr. Anderson's statement, from half an inch to more than a yard in diameter; it includes the genera *Phylloceras*, *Gaudryceras*, *Tetragonites*, *Turrilites*, *Baculites*, *Knemoceras* (?), *Forbesiceras*, *Acanthoceras*, *Desmoceras*, *Puzosia*, and *Nautilus*, with many new forms, the number of forms of *Acanthoceras* being particularly noteworthy.

Compared with the fauna of the nearest outcrop, viz., that described under the title of "The Umsinene River Deposit, Zululand," the False Bay deposit has not yielded any specimen resembling either the Hamite or the examples doubtfully referred to the genus *Douvilleiceras*, but the specimen recorded from the Umsinene River deposit as *Desmoceras* sp. resembles some of the forms which are described from the False Bay deposit as *Pusosia*, although it does not actually agree with any one of them. The fauna of this deposit does not include any of the forms which have been recognized in the Umkwelane Hill deposit, some 40 miles to the south; nor any of those recorded from the Umpenyati strata still further south; nor any of the species described from the Cretaceous rocks in Pondoland. The relation of the False Bay fauna to that of the Mannan Creek deposits, which are only at a comparatively short distance, is referred to below.

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[1] This tributary is not named in the map accompanying this paper; from Mr. Anderson's description it appears to be the stream which is named the Unywana River in the Geological Sketch-maps of Zululand issued with the First and Second Reports respectively.

To the north of Zululand Professor Kilian[1] has recorded the occurrence of an Aptian fauna at Delagoa Bay, but the False Bay fauna contains no Aptian forms. Still further to the north, from rocks near the mouth of the Conducia River, which debouches into the Indian Ocean a little north of Mozambique, M. Paul Choffat[2] has described a fauna composed principally of Cephalopods, the age of which he regards as from Vraconnian to Cenomanian. M. Lemoine[3] considers them to be of Cenomanian age. Some of the forms closely resemble some of those from the False Bay deposit.

The fauna from the north end of False Bay is undoubtedly of Cenomanian age.

The Cenomanian fauna which has been recorded,[4] and is being described,[5] from the north of Madagascar, presents a striking resemblance to the False Bay fauna. Several of the species which, up to the present, have been characterized, are represented in the False Bay deposit, and doubtless when the whole fauna has been described the similarity between the two faunas will be very apparent.

The False Bay fauna also shows great analogy to that of the Utatúr Group in the Trichinopoli district of Southern India, particularly with its Middle and Lower portions. According to Dr. Kossmat,[6] the equivalents of this group are as follows:—Upper Utatúr = Lower Turonian; Middle Utatúr = Upper and Middle Cenomanian; Lower Utatúr = Lower Cenomanian (Vraconnian).

The False Bay fauna also exhibits analogy to that of the Cenomanian of Europe.

Other Cephalopoda also described by the present writer in the same Report are recorded under the title "The Cephalopoda from the Tributaries of the Manuan Creek, Zululand." Most of these, principally Nautili, were stated to have come from the "South Branch, Manuan Creek," a few only being labelled "Crossing Middle Tributary, Manuan Creek." It would appear, however, from Mr. Anderson's remarks in the Report which has just been issued (p. 59) that all the specimens which the present writer has described from the "Tributaries of the Manuan Creek" were obtained from the deposit which has been referred to above[1] as occurring on the left-hand bank of the middle tributary. "The outcrop," says Mr. Anderson, "is a very small outlier, exposed on the slope of the northern bank of the creek, and is completely isolated on the Rhyolite. This exposure passes along the north side of the creek for a distance of a few hundred yards. The strata, as exposed in the cliff, which is about 20 feet in height, consists of a dirty grey-brown calcareous sandstone, which contains the chief specimens of the Cephalopoda, both Ammonites and Nautili. Below this, about 15 feet of shales and marls, chiefly containing Mollusca and other forms." Since the matrix of the specimens marked "South Branch, Manuan Creek," agrees with Mr. Anderson's description of the upper part of this deposit, it would seem that they were obtained from this portion, whilst the few fossils labelled "Crossing Middle Tributary, Manuan Creek," may have been obtained from the lower portion consisting of shales and marls. At any rate, the few specimens labelled "Crossing Middle Tributary, Manuan Creek," seem to indicate a somewhat lower horizon than the fossils labelled "South Branch, Manuan Creek." The fossils from this deposit are as a rule fragmentary and very imperfectly preserved. The general facies of this fauna differs somewhat from that of the False Bay fauna; the latter is characterized by an abundance of forms of *Acanthoceras*, the fauna of the upper part of this deposit by the prevalence of Nautili. Whether the fauna of the upper part of this deposit is simply another facies of that found at False Bay is not quite certain; it may be, or it may possibly indicate, a somewhat higher horizon, but the specimens labelled "Middle Tributary, Manuan Creek," that we believe to be from the lower portion of this outcrop, seem to show the existence in this deposit either of the lower portion of the beds which are exposed at False Bay, or even of a slightly lower horizon.

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[1] W. Kilian: "Sur quelques gisements de l'étage aptien," Bull. Soc. géol. France, sér. IV, ii (1902), p. 358; "Sur le présence de l'étage Aptien dans le Sud-Est de l'Afrique," Comptes rendus, cxxxv, No. 1 (7 Juli, 1902), pp. 68–71; "Ueber Aptien in Südafrika," Centralbl. für Mineral. Geol. und Palaeont., No. 15 (August 6, 1902), pp. 465–8.

[2] Paul Choffat: "Contributions à la connaissance géologique des colonies portugaises d'Afrique: I. Le Crétacique de Conducia," 1903. (Com. Serv. géol. Portugal.)

[3] P. Lemoine: "Études géologiques dans le nord de Madagascar," 1906, p. 396.

[4] For references see P. Lemoine: "Études géologiques dans le nord de Madagascar," 1906.

[5] M. Boule, P. Lemoine, and A. Thevenin: Ann. de Paléont., i.

[6] F. Kossmat, "Die Bedeutung der südindischen Kreideformation, etc.": Jahrb. d. k.k. geol. Reichsanst., Wien, Bd. xliv (1894), Heft. iii and iv (April, 1895), p. 460; and Records Geol. Surv. India, xxviii, pt. 2 (May, 1895), p. 40.

A review of the faunas obtained from the several exposures of Cretaceous rocks in Natal and Zululand seems to confirm Mr. Anderson's statements (Third Report, pp. 48–49): (1) that "all the fossils obtained from the various localities where exposures of these rocks have proved fossiliferous, in Natal and Zululand, belong to the Upper portion of the Cretaceous System"; and (2) that "so far as our present knowledge goes, no representatives of the Lower Cretaceous have yet been proved in Natal or Zululand." The beds near the mouth of the Umpenyati River in Natal are evidently of the same age as the Pondoland deposits, whilst the beds which are found in the southern part of Zululand, at Umkwelane Hill and in the boring north of the Umhlatuzi lagoon, are probably also of the same age. Further north, however, near the north end of False Bay, rocks of Cenomanian age occur, and to the west of these, in the neighbourhood of the Manuan

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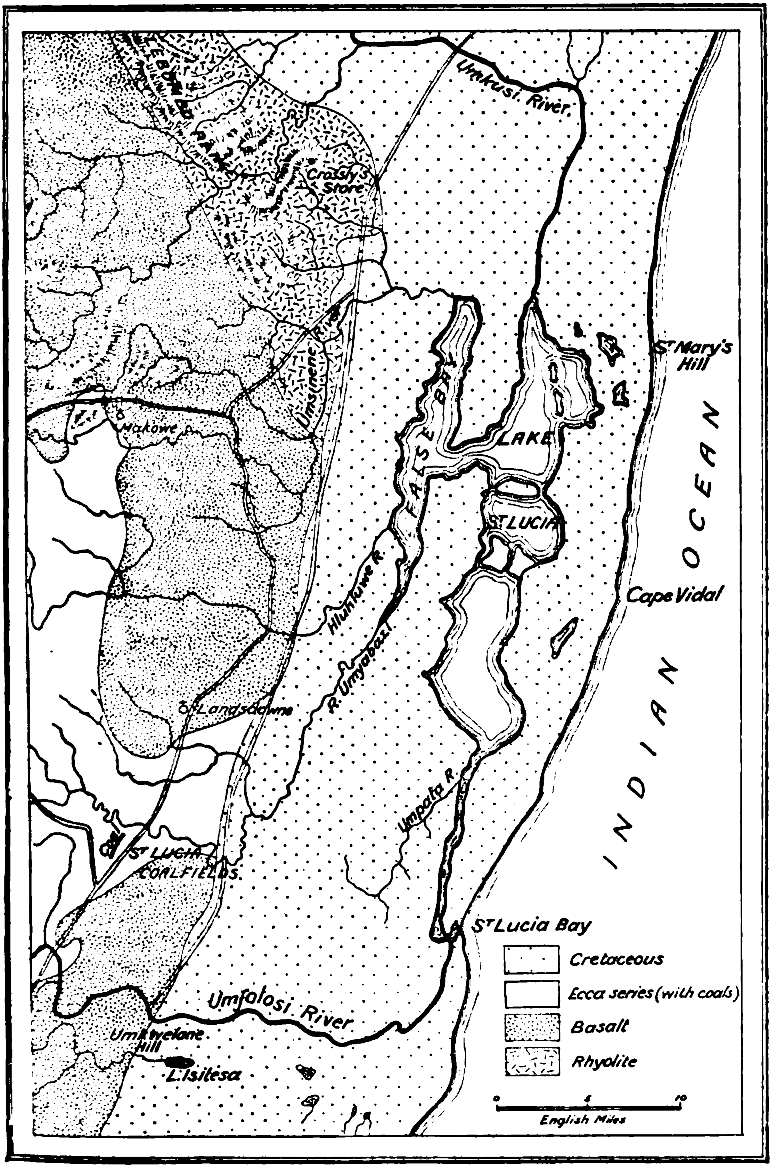
[1] See *ante*, p. 340.

Creek and its tributaries, beds of the same age, passing down possibly into rocks of Upper Albian age, are probably also present. The occurrence here of Cretaceous beds of an age younger than Cenomanian is somewhat doubtful.



Geological Sketch-map of part of Zululand. (After W. Anderson.)

III.—GLACIATION AND PHYSIOGRAPHY IN THE NORTH-EAST OF ANGLESEY.[1]

By EDWARD GREENLY, F.G.S.

(WITH A SKETCH-MAP.)

THE general direction of glaciation in the north-east of Anglesey is from about N.N.E. to S.S.W., with local variations of a few degrees on either side. These are but of minor importance, the general trend being remarkably steady, so much so as even to indicate beforehand the existence and approximate position of unknown occurrences of certain rocks by thin trains of boulders.

When surveying the country about Llanerchymedd and Rhosgoch, I was, therefore, much perplexed by finding large numbers of fragments of Carboniferous Limestone. For these could not have invaded that district if carried from the known exposures of that rock by ice moving in the direction mentioned: as will be evident from a glance at the annexed sketch-map (p. 349).

I even made enquiries from leading farmers whether it was possible that they might have been brought in imperfectly burnt lime used in agriculture in former times; for none had then been found in the boulder-clay, but only upon the surface. The farmers thought this was possible, and for a while I rested in that view. But fragments of the local Old Red Sandstone then turned up, and last summer, in particular, a mass of it no less than 10 feet long, lying on the north-west shore of Dulas Inlet, which was even there a little too much to the north for the prevalent trend. These, at any rate, were not brought artificially. Besides, the Boulder-clay at the mouth of Dulas Inlet is decidedly red. Now, at Porth Gwichiaid, some distance to the north, there is an excellent section in Boulder-clay, and in this I found unmistakable boulders of Carboniferous Limestone with crinoids, beautifully ice-worn, besides many others of sandstone and conglomerate of Carboniferous type. Here, at any rate, there could be no doubt.[2] From no visible outcrop could these boulders have been derived, and it is evident they have come from out of the sea.

If, now, we produce the base-line of the Carboniferous Limestone from where it reaches the coast to the little island in Dulas Bay where the tower of shipwreck-refuge is, we shall see that it is curving somewhat to the north and west, instead of running out on a north-east strike as might have been expected; and if we further produce this line, following the curve thus indicated, we shall find that it sweeps round the north-east of Anglesey at no great distance from the land.

This, then, is the source of the boulders of Port Gwichiaid, and this is the source of the much more numerous boulders that are scattered far and wide over the country about Rhosgoch and Llanerchymedd.[3]

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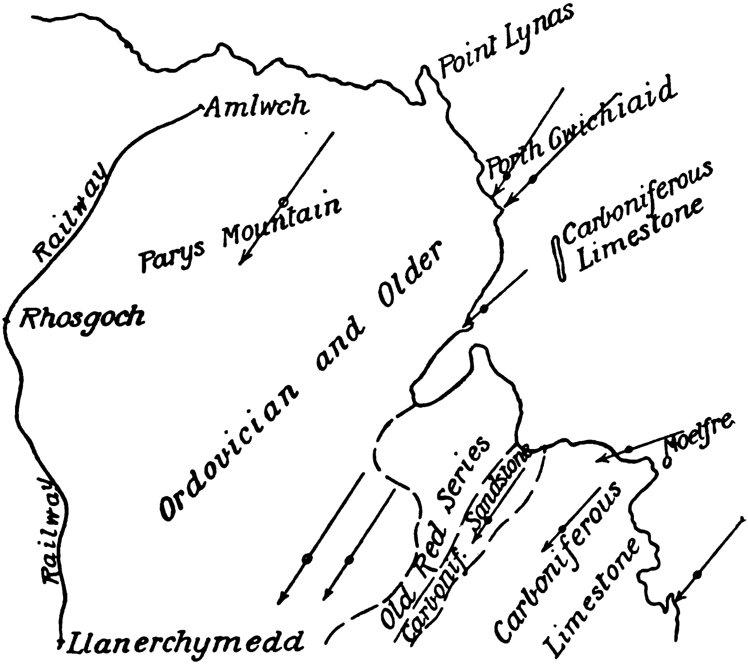
[1] As the end of my work in Anglesey is now within sight I may perhaps say that this and other short papers already published are portions of continuous glacial work in the island. Since coming there some twelve years ago I have put the drift lines and allied information upon the six-inch maps as well as the 'solid' geology, and from these a connected account of the glaciation of the island can be given.

[2] There seems to be an older set of striæ at one place running W.S.W., but this is under high land, and is evidently a local deflection.

[3] As large tracts of that country are above the 200 feet contour, we have here another case of those uplifts of boulders of which I have now on record a good number of examples in the island.

Further, on examination of the Porth Gwichiaid Boulder-clay, as well as that at Dulas Inlet, I found that the rest of its contents consisted of rocks foreign to Anglesey, with some of local Ordovician type, but that fragments from the Schistose Complex were rare or almost absent. The Schistose Complex cannot therefore extend to any distance beneath the sea to the north-east; indeed, the limit must coincide very nearly with the present coastline.

Now, on reference to the sketch-map, it will be seen that the submarine curve we were considering runs as nearly as possible parallel to that of the coast itself as far as Point Lynas. To the east and north-east, therefore, it is clear that the existing land of Anglesey coincides very nearly with the limits of the old Crystalline and Ordovician Complex, and that the Irish Sea in that direction is floored by Carboniferous and probably also by later rocks.



Sketch-map of North-East Anglesey. The arrows indicate the direction of glaciation. Scale, two miles to an inch.

IV.—“How Long Ago” in Geology.

By Edward A. Martin, F.G.S.

One is frequently asked the question, how long ago is it since certain geological phenomena took place in which the questioner is interested for the time being. How long ago were the great coal-beds deposited, or how long ago is it since the chalk was formed at the bottom of the sea?

Now, dates in geological history cannot be given with any degree of certainty. The amount of conjecture in proportion to the amount of fact must be very large indeed; yet even a rough estimate is not without its value, since it may give an idea of the really comparatively short space of time in geological history during which some of the best-known formations were laid down.

Geologists will for a long time differ amongst themselves as to what term of years has elapsed since a solid crust had formed on the surface of our globe, when life as we know it had first begun to be, and when denudation and all that it means had commenced to operate, and in embossing upon the surface of the earth the scenery as we now see it. Things have changed since geologists were asked to limit themselves to 20 millions of years as the period during which all the sedimentary formations were laid down. Professor Huxley's willingness to confine himself to 100 millions of years is not altogether concurred in, now that the discovery of the great energy lying dormant in the various radio-active bodies has shown the possibility of a much greater age being assigned to the sun as a heating luminary over and above that hitherto supposed. I am justified from many points of view in assuming that a solid crust had formed about 250 million years ago, that strata have formed at an average rate of one foot in 700 years, and that the older the rocks the more the strata have been compressed into thinner layers. We must also not only consider in our discussion the number of years which known strata took to form, but the years which are represented by the great gaps between the formations when no deposition was taking place but when great changes were taking place in the evolution of life.

Adopting Sollas' measurements of known strata, and placing against each formation the number of years which it approximately represents, we shall have the following table (see p. 351). For all strata below and including the Devonian I have allowed an addition of 50 per cent. for compression subsequent to deposition. For the Carboniferous, Permian, and Triassic I have added 25 per cent. for the same reason, and from the Jurassic to the Oligocene 10 per cent. For deposits between the Miocene to the Recent inclusive I have left the thicknesses as estimated by Sollas, since the rate of deposition may in some portions have been less than the estimated rate already mentioned, and in other parts there may have been compression as in older formations. The relative proportion of each formation to the rest will be found in column three.

We shall find from this table that approximately the great Coal age came to a close 70,495,000 years ago, and the Chalk age (Cretaceous) 31,680,000 years ago. It will also be seen that an enormous period had elapsed before the earliest formation commenced to be laid down in which fossil life is decipherable, viz. Cambrian. The earlier great American formations, included in which is the older-named Laurentian, show a space of time of 86,100,000 years.

It is interesting to note the years which have been necessary according to this table to evolve the various forms of life. The evolution of the trilobites of the Cambrian was accomplished in about 86 millions of years. The six-feet-long Crustaceans and mudfish of the Old Red Sandstone took 136,500,000 years to arrive upon the scene, and the small reptiles of the coal era were the outcome of 159,600,000 years. The winged reptiles of Jurassic times took 21,875,000 years more to be evolved, whilst the small marsupial mammals of the same period were followed in another 16,940,000 years by the great mammals of Eocene times. And then came the crowning of the evolutionary movement by the appearance of the human species in Pliocene times.

SYSTEM.	ACTUAL THICKNESS IN FEET.	BEFORE COMPRESSION.	RELATIVE PROPORTION.	YEARS.
Pleistocene and Recent	4,000	4,000	4	2,800,000
Pliocene	5,000	5,000	5	3,500,000
Miocene	9,000	9,000	9	6,300,000
Oligocene	12,000	13,200	13·2	9,540,000
Eocene	12,000	13,200	13·2	9,540,000
Cretaceous	14,000	15,400	15·4	10,780,000
Jurassic	8,000	8,800	8·8	6,160,000
Triassic	13,000	16,250	16·25	11,375,000
Permian	12,000	15,000	15	10,500,000
Carboniferous	24,000	30,000	30	21,000,000
Devonian	22,000	33,000	33	23,100,000
Silurian	15,000	22,500	22·5	15,750,000
Ordovician	17,000	25,500	25·5	17,850,000
Cambrian	16,000	24,000	24	16,800,000
Keweenawan	50,000	75,000	75	52,500,000
Penokee	14,000	21,000	21	14,700,000
Huronian	18,000	27,000	27	18,900,000
	265,000	357,850	357·85	251,095,000

In the above table notice has been taken only of actual strata in calculating the various ages, and no mention has been made of the great breaks in life-history which are noticeable in studying fossil remains, and these breaks may—indeed, in some cases must—represent great periods of time. Their actual duration could only be arrived at by discussion and agreement among geologists, but it is of course well recognized that the greatest breaks in the continuity of life occurred between the Permian and the Triassic systems and between the Cretaceous and the Eocene.[1] The very fact, however, that different names have been necessary in alluding to the systems suggests a possible break between each, and presuming that we must confine ourselves to about 250,000,000 years, as already shown, we must find room for the gaps during which no strata were deposited, by deducting some of the years allotted to each formation.[2]

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[1] The principal *unconformities* have been considered and estimated for by the late Mr. J. G. Goodchild in his "Evidence regarding the Age of the Earth" (see Review in GEOL. MAG., 1897, pp. 415–417), Edinburgh, McFarlane & Erskine, 1897, and Proc. Roy. Phys. Soc. Edinburgh, vol. xiii, pp. 260–303.

[2] Mr. Goodchild liberally allows 70,200,000 years for *three* well-recognised *breaks* in his geological series, and for the whole period of geological time he suggests 704,235,000 years.

NOTICES OF MEMOIRS.

I.—The Geological Aspects of South African Scenery. Presidential Address delivered to the Geological Society of South Africa by Dr. Geo. S. Corstorphine, B.Sc., F.G.S.[1]

NO country affords readier facility for the observation of the geological causes of scenery, though we may regret the fact that the facility owes its existence largely to the deplorable destruction of a former vegetation.

South African scenery is striking in its very monotony. Over hundreds, or rather thousands, of square miles there is a sameness which becomes oppressive, and a want of variety of feature which exceeds all imagining. There is nothing stimulating in the landscape but its immensity, yet, owing to the limited horizon, that immensity is not a characteristic immediately appreciated. The fascination of the veld is subtle and elusive, probably because, more there than anywhere else, is the charm due to conditions of sunshine and atmosphere, factors as essential to the final effect of a landscape as the configuration of the earth's surface.

The geological constitution and structure are the fundamental conditions on which the scenery of a country depends, and the resulting landscape is the outcome of the work done by the agents of denudation, which are themselves mainly due to the prevailing climatic conditions. Denudation working on the original structure, finding out the weak spots and gradually carving away even the hardest rocks, is the great factor in the evolution of a landscape. Whether that denudation is of one type or another, whether its weapons are rain, running water, snow and ice, or whether extremes of temperature aided by torrential tropical rains are the main modifying influences, depends on the climatic conditions. Similar geological conditions in regions enjoying different climates are subjected to different denuding forces, with the result that varied types of scenery are produced.

In a region such as South Africa, where the same geological formations extend from the Atlantic to the Indian Ocean, and from Agulhas to the retreating boundary of 'Darkest Africa,' the resemblances in the scenery are produced by the prevailing geological uniformity, and the differences are due to the variations in the climate.

It is to the action of long-continued subaerial denudation that South African scenery owes most of its characteristic features. Geological investigation reveals the fact that long ages have elapsed since the main stratigraphical structures originated, and that even the present land surface has an antiquity for which any possible equivalent in years would convey no meaning to the human understanding, for since the upper beds of the Karroo System were deposited only a small portion of the coastal region has undergone submergence.

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[1] Annual General Meeting, 28th January, 1907 (Proceedings of the Geological Society of South Africa, 1907, pp. xix–xxvii).

The present surface, here as elsewhere, is the last expression of the interaction of various geological forces, some of which are as active to-day as they probably ever were, while others have in these days no share in the sculpturing of this landscape. Changes of temperature, wind and rain, surface and underground water, are probably not much less active in South Africa to-day than in past ages; whereas extreme glacial conditions have played no part in modifying the surface since the beginning of the Karroo Age, nor have volcanic agencies been at work since the eruption of the rocks of the Drakensbergen and the Lebombo Range.

The record of the South African strata tells us that before the present conditions began there were five periods during which a land surface existed. The earliest of these, and yet not the first, was formed by the complex mass of old rocks, now largely metamorphic in character, which we group together as the Swaziland System. To-day again these rocks play a large part in the constitution of the region, but whether any portion has remained continuously a land area cannot be determined. Certainly the northern granite and schist regions were dry land while the central and southern areas were gradually covered by the sea in which the Witwatersrand Beds were laid down. These beds in turn were added to the land surface, and in the process of upheaval they underwent considerable folding and contortion. Having been again submerged, portions of the granite area, and probably the whole Witwatersrand System, formed the floor for the heterogeneous Ventersdorp System, with its succession of sediments and volcanic rocks, which in turn formed the third land surface that plays a part in the present one. When the next submergence ensued, the Black Reef, the Dolomite, and the Pretoria Series were deposited in the northern areas, which we know as the Transvaal, Bechuanaland, and Northern Cape Colony, though whether land conditions prevailed southward, or whether these beds were also deposited there, but were subsequently denuded, is again a matter of conjecture. At any rate, the evidence now available points to little deposition having occurred in the south during that period.

In the land surface next formed, the Swaziland, the Witwatersrand, the Ventersdorp, and the Potchefstroom or Transvaal Systems all played some part, there being a gradual increase in complexity from the north southward.

During the next submergence there was deposited the Cape System, consisting of the Table Mountain, the Bokkeveld, and the Witteberg Series, so predominant throughout Western and Southern Cape Colony, but represented in Natal by the Table Mountain Series only, and in the Transvaal most probably by the Waterberg sandstones and conglomerates.

When this period of deposition ended, the present terrestrial conditions began to prevail, for the characteristic Karroo System was not due to marine action, but, as is universally recognised, was formed mainly on the floor of an inland lake, while in the north land ice caused the extensive morainic deposit of the Ecca Glacial Conglomerate. This inland lake must have covered the greater portion of the region, and its shores certainly extended considerably south of the

Karroo, for we find its deposits in the Breede River Valley, south of the Langebergen. It seems likely that the lacustrine conditions prevailed longest in the east, north-east, and north, for it is only there that the Stormberg Beds, the youngest division of the Karroo System, are found, and we have no reason to believe that their absence in the south and west is due to denudation.

The disappearance of the Karroo Lake was probably accompanied by, if not actually due to, the upheaval of the only true mountain chains which characterise South African scenery, and it was doubtless during the same period of disturbance that the enormous volcanic activity now represented by the lavas of the Drakensbergen had its origin. The fossil evidence shows that this final upheaval most probably occurred in Jurassic times.

The submergences which occurred later affected only the coastal belt of the country, and are represented by the relatively small patches of Cretaceous rocks occurring in Cape Colony, Natal, and Zululand, and the strip of Tertiary beds on the coast of the last-named province. Throughout the greater extent of Secondary and Tertiary times the larger part of South Africa has been a land surface, and it is no wonder that its landscape should, to such an extent, show features due to denudation.

The present scenery has originated from the accretion of remnants of successive formations, each to a large extent formed by the disintegration of such portions of its predecessors as could be affected by the complex agents of denudation, while the sum-total as presented by the land of to-day is undergoing continuous modification by the denuding agents now at work.

For the present purpose South Africa may be regarded as falling into three zones—the Coastal Zone, the Mountain Belt, and the Interior Plateau.

The Mountain Belt.—The Mountain Belt is well developed in the west and south, and, as it is the essential feature in the structure of South Africa, I shall deal with it first. It embraces all the mountains which trend north and south on the western border of the Karroo and the various ranges which run east from Hex River Pass to the vicinity of Algoa Bay. This extended area consists of a series of true mountain chains, showing as much intricacy of structure as the Alps of Central Europe. The most conspicuous geological component is the Table Mountain Series, but the two higher members of the Cape System also play a part, while on the internal boundary of this zone the lower beds of the Karroo System are included in the mountain folds. Sections showing true mountain structure are to be seen in such places as Mitchell's Pass, Hex River Pass, and in the various passes and river gorges which cut the mountain chains from north to south, such as the Montagu and Prince Alfred's Pass over the Langebergen and the Gamka River Poort and the Zwartberg Pass through the Zwartebergen. Mountain scenery of the wildest and grandest type is to be seen among the Zwartebergen, the Langebergen, and the intervening ranges. Denudation has played a large part in the production of the present scenery, for the summits of all these ranges consist of Table Mountain quartzites, the geologically higher

Bokkeveld Beds being confined to the flanks of the mountain chains, or even to the valleys, while the more quartzitic Witteberg Beds may form subsidiary ridges. On the south-western coast of Cape Colony, and at intervals eastward to Algoa Bay, the mountain belt virtually reaches the coast: the Cape Peninsula itself is an outlying remnant, having been cut off by denudation from the hills on the western shores of False Bay.

The South Africa of to-day has lost a considerable portion of the mountain belt beneath the waves of the Indian Ocean, for from Algoa Bay northward through Natal we have no longer the same marked mountain scenery. Where the Table Mountain Beds appear in Natal they are lying for the most part horizontally, and though they form what are locally termed mountains, these, like the Cape Peninsula, are on the outskirts of the region of extreme pressure, which in eastern South Africa probably lies beneath the ocean.

Between such portions of the mountain belt as still exist in Natal and the more typical Langebergen and Zwartebergen of Cape Colony the contrast is very marked. In Natal the valleys are not structural valleys, but have been produced by the cutting out of great masses of the strata. The mountain tops are plateaux, formed of horizontal beds, whose edges form the sides of the deep-cut valleys.

The mountain belt being composed essentially of quartzites, those portions of it in the more arid districts of Cape Colony yield a very stern, bare landscape. In the east of Cape Colony and in Natal, however, the moister climate renders vegetation abundant, and we find the rocks of the mountain belt covered by bush, and even forest.

The Coastal Zone.—The Coastal Zone varies considerably in character, and, as has been already stated, it is in places actually cut out by the encroachment of the mountain belt. On the west coast it is perhaps most typical, consisting there of the old slates and schists of the Namaqualand Series, with bosses of intrusive granite. It presents a low undulating landscape, broken by hills of granite, which in places, as at Paarl and Robertson, are conspicuous features.

Along the west and south coasts, bare sand dunes are abundant, and some of the older of these have solidified into coherent masses, which are again being cut into by the sea. On the north shore of False Bay, and near Struys Bay, Cape Colony, there are cliffs 20 to 25 feet high, formed of these old sand dunes.

Where the mountain zone has encroached on the coast, as on the shore of False Bay, and many places eastward, the Table Mountain quartzites form steep sea cliffs.

The eastern coast of Cape Colony and of a considerable portion of Natal is formed by the rocks of the Karroo, which, however, are much covered by recent coastal deposits. The lagoon landscape is particularly well developed along the Natal coast, owing to the heavy banking up of sand bars at the river mouths, while the Zululand coast is for the most part a low-lying belt.

The variation in the scenery produced by differences of climate acting on the same geological formations is again well illustrated in the coastal zone. The granitic and schistose rocks of the north-west, being exposed almost to desert conditions, show a bare and uninteresting scenery—low undulating hills with a marked absence of river valleys. From the district of George eastward, and northward into Natal, the more generous rainfall renders forest vegetation possible; the granite tors and barren schist areas of the west are unknown, and numerous rivers flow seaward in deep-cut valleys. On the Natal coast the vegetation is still more abundant, and much of that area has an almost tropical character, though the geological formations are identical with those of the barren west coast.

The Interior Plateau.—The third area—the Interior Plateau—is the most extensive and also most varied in South Africa, showing the greatest diversity both of scenery and of geological constitution.

In the Cape Colony it consists of the Karroo, with its desert conditions, which disappear as one passes north-eastward into the Orange River Colony and the Southern Transvaal, though the same geological horizons prevail throughout these areas. Northward, the High Veld of the Transvaal consists, in addition to the Karroo Beds, of an extensive area where the older rocks, down to the oldest formation of all, have been laid bare. To discuss briefly the scenery of this vast interior plateau, it will be advantageous to deal first with the Karroo proper, and then the other areas built up of the rocks of the Karroo System.

The great Karroo is one of the most characteristic features of South Africa, and though its scenery may not be inviting, we may remember that it was the Karroo fossils sent home by Andrew Geddes Bain which first excited keen geological interest in South Africa, an interest which was stimulated on other sides by the controversy over the marvellous basal glacial conglomerate, while it was with the discovery of the Karroo diamonds that South Africa's importance to the modern world began.

The Karroo is built up of sandstones and shales which, except in the extreme south and west, where the lowest members of the series have been involved in the folding of the mountain belt, lie horizontally. Basic igneous intrusions, belonging to a late period in the geological history of the region, are everywhere abundant throughout the Karroo rocks. The Karroo scenery is a true denudation landscape. The hills which abound are remnants carved out from a surface once much higher. The flat-topped hills are in the earlier stages, the pointed ones in the later stages, of disintegration. The interbedding of harder sandstones with soft shales gives the alternate cliffs and slopes on the hillsides, while sheets of dolerite make the more marked escarpments, or krantzes.

Along the south of the Karroo, and well seen between Touws River and Matjesfontein, the slab-like weathering of the Glacial Conglomerate gives the hillsides a peculiar appearance.

The change of scenery which occurs from about the centre of the Orange River Colony northward into the central Transvaal coincides with the predominance of softer, more felspathic, sandstones, and the practically unbroken aspect of this portion of the High Veld is due to the more regular and homogeneous weathering which there occurs. There is not the same alternation of hard and soft rocks as in the Karroo proper, and the less arid climate enables the veld grass to protect the soil.

The whole of the central plateau, where the Karroo sandstones and shales form the surface, shows numerous ridges, scarcely to be called hills, which mark the site of basic igneous intrusions, which can often be traced for miles across the country. The west and south-west of the Orange River Colony often presents what may, on a small scale, be termed quite a rugged landscape, owing to the abundant presence of dykes and small irregular bosses of dolerite and allied rocks, which, even when forming no great elevation above the general level, stand out conspicuously from the grassy veld by reason of their dark colour and their growth of sparse bush.

The central Transvaal has been largely stripped of its covering of Karroo rocks, and the old rocks appear as mountain ridges, which are in every case a reappearance of a part of one of the older land surfaces. In this portion of the country, whether the rocks belong to the Witwatersrand System or the Potchefstroom System, the resulting scenery is practically identical—low, but abrupt, escarpments of quartzites, with dip slopes inclining north or south, and forming one side of a valley which has been carved out of the softer slates or shales. The Gatsrand, the Witwatersrand, the Witwatersberg, and the Magaliesberg are all instances of this type of scenery—east and west ridges with their escarpments facing north or south according as the beds dip south or north respectively. Each intervening valley has on one side a gentle declivity and on the other a steep precipitous wall.

In contrast to the long lines of sedimentary escarpments, which make many of the hills in the southern Transvaal, are the irregular masses of Ventersdorp amygdaloid, forming the Kliprivérsberg and the hills south-east of Heidelberg, while north of the Witwatersrand there is the undulating landscape due to the presence at the surface of a large extent of the old granite.

Beyond the Magaliesberg, where the great Bushveld massif of igneous rocks appears at the surface, the landscape opens out again into the broadly undulating type. The more basic of the rocks often form hills, such as the Pyramids or Zwartkopjes north of Pretoria, but the granitic rocks give a scenery differing in no wise from that of the old granite, or, in fact, of any non-mountainous granite area. These rocks form a large part of the Bushveld proper, which in many places, with its grassy surface and irregularly dotted trees, has a close resemblance to the scenery of an English park.

Where the Waterberg formation appears resting unconformably on the Bushveld igneous rocks, or on the old granite of the north, there is a return to the escarpment and dip valley type of landscape, which is well seen in the hills north of the Premier Mine, the Waterberg itself, and the Zoutpansberg still further north. In all these hills the reddish-brown colour of most of the Waterberg conglomerates and quartzites is always a conspicuous feature.

By far the larger portion of the northern Transvaal is a granite landscape, presenting over thousands of square miles a gently undulating surface, with occasional bare tors rising like inverted bowls above the surrounding country. It is, except in rare seasons, a dry country covered by straggling thorn trees, above which rise the grotesque limbs of the fantastic baóbab.

The same type of country extends northward into Rhodesia, and westward into Bechuanaland. In the former territory schist and slate ridges often form conspicuous escarpment hills, as along the Mazoe Valley, but it is the exception to find the granite rising into elevations which might rightly be styled hills. In the Transvaal, however, east of Louis Trichardt in the Letaba Basin, there are some conspicuous granite peaks, while the Matopos and the hills of the Lomagundi district, in Rhodesia, are other instances. All these, however, differ from such mountains as the Central Alps, in being due to the denudation of the surrounding country, and they can in no sense be regarded as true mountains of elevation.

The whole of the central plateau is a poorly watered country. The Karroo, in Cape Colony, has not a single perennial stream, and the rivers of the Orange River Colony are little better. Even the Vaal and Orange Rivers are, for the greater part of each year, only a series of standing pools over a large part of their upper, and often over their lower, courses. The best-watered regions are where the dolomitic limestone of the Potchefstroom System prevails, either in the southern or in the eastern Transvaal.

Few of the other rivers present much of the nature of river scenery as known in European countries. Those of the Karroo have broad shallow courses, covered with the boulders brought down in the rare times of flood. In the Orange River Colony many of the rivers have cut deep channels through the soil and soft surface deposits, but rocky gorges are not common, though good instances may be seen on the Caledon River on the Basutoland border.

The edge of the central plateau in eastern South Africa makes a marked physical feature, especially where it forms the great escarpment of the Drakensberg. But everywhere there is a more or less sudden drop from the High Veld down to the low country of the eastern coastal belt, whether over the basal granite, as in the Letaba Valley and at Waterval Boven, on the Delagoa Railway, or over the uppermost beds of the Karroo System, as in Natal and the Transkei.

The passage of the rivers from the central plateau to the coast zone presents considerable variation. In Cape Colony they have cut deep gorges through the Zwartebergen, Langebergen, and intervening ranges, but in Natal and the eastern Transvaal lofty waterfalls over the edge of the plateau are the common feature.

South Africa is absolutely devoid of lakes—such bodies of water as are often designated lakes being lagoons along the coastal belt, as in the George and Knysna districts, Cape Colony, and in the case of Lake St. Lucia, Zululand; or, like Lake Chrissie, in the eastern Transvaal, they are shallow depressions filled by rain-water in the wet years—in fact, simply enlarged pans.

Many interesting observations are readily possible as to the modifications now taking place of the scenery whose geological basis I have thus briefly sketched. Over a large tract of country rock-masses break up by alternate expansion and contraction due to the wide daily variation of temperature from noon to midnight throughout a large part of the year, and whether we look at the crumbling shales of the Karroo kopjes or the massive granites of the Matopos, the same destruction is visible.

Even more obvious is the result of the torrential rains over the central plateau: we see channels cut or deepened before our eyes, and the soil of the country is carried seaward in vast quantities during every rainy season. The general surface, especially when the rain has been aided by wind, shows sometimes coverings of sand, sometimes fine gravel, decomposed from the surrounding rocks, and there are many places where this material has been accumulated to such an extent that it is often assumed to be due to an ancient river.

The intensity of these processes to-day is largely due to the scantiness of the vegetation, which is not always natural, but has been caused by the ruinous custom, almost universally observed, of burning off the grass at the end of each Summer season. Instead of such senseless destruction of Nature's own protective covering, we might hope that it would now be realised that we need to add to, and not diminish, the vegetation of this part of the earth's surface. As geologists, we should willingly sacrifice our interest in observing the rapid action of denudation, when the first of each season's rains beat down on, and wash away, the soil laid bare through the destruction of grass or bush, for the knowledge that the land was not being wantonly impoverished year by year. We should even be glad to see many of these surface features, which are now so easily referable to their underlying geological features, hidden from us by a kindly growth of vegetation, and we should welcome a wise system of afforestation throughout the entire land.

In conclusion, gentlemen, I think you will agree with me that the natural and the political South Africa present some striking contrasts: geologically this part of the world has reached a maturity which no human system can hope to attain, politically the entire country is in an embryonic stage; geologically the region is the one throughout, but politically we have dismembered it. It appears almost as if Nature's plan had been too vast; her scheme too grand for poor humanity. Certainly, if the character of the people who have their home in South Africa develops in accord with the natural environment, pettiness of view or paltriness of aim will not be national traits—a country whose foundations are so wide cannot be the home of other than a broad-minded, large-hearted race, bound to play no mean part in the history of the world.

II.—General Report of the Geological Survey of India for the year 1906. By T. H. Holland, F.R.S., Director. (Reprint from Records, Geol. Surv. India, vol. xxxv, part 1, April, 1907.)

IN the Introduction to his Report Mr. Holland states that "The great development of interest in Indian mineral deposits, as shown by the remarkable increase in the applications for concessions reported by the Local Governments, has had an effect also on the office work of this Department, and the duty of answering enquiries, instead of being a mere addition to the work of the officers at head-quarters, as was formerly the case, now consumes the largest fraction of our time."

It is satisfactory to learn that the Rt. Hon. the Secretary of State has sanctioned an increase in the graded list of gazetted officers, and the creation of a special post of chemist. The temporary posts for Mining Specialists have been abolished, in order to permit the appointments of permanent officers with a knowledge of mining. In order to assist in the development of the mineral resources of India, Mr. Holland visited during the year certain metallurgical and chemical works in England and Ireland.

Attention is drawn to the occurrence in India of highly aluminous laterites or bauxites that may prove to be valuable as a source of aluminium. Various other ore-deposits and economic products are referred to.

Investigations have been commenced with the view of supplying data on the problem of denudation, by determining the amounts of silt and dissolved salts carried into the sea by the larger rivers of India, and observations with this object were made on the Indus river.

Mr. E. Vredenburg, who was last year appointed Palæontologist to the Indian Geological Survey, has devoted attention to the fossils of the Lower Tertiary formations; Mr. F. R. Cowper Reed has completed an examination of the Devonian fossils collected in the Northern Shan States; and Professor Carl Diener has dealt with the collections of Muschelkalk fossils.

In Petrology assistance has been given by a former member of the staff, Dr. T. L. Walker, now Professor of Mineralogy and Petrology in the Toronto University.

Field-work was carried on in the Andaman and Nicobar Islands, in Baluchistan, Burma, Central India, and Kashmir, and the results of many interesting and important observations are summarized.

REVIEWS.

I.—The Scenery and Geology of Devonshire.

The History of Devonshire Scenery: An Essay in Geographical Evolution. By Arthur W. Clayden, M.A., Principal of the Royal Albert Memorial College, Exeter. 8vo; pp. viii, 202, with 43 illustrations. (Exeter, J. G. Commin; and London, Chatto & Windus, 1906. Price, 10*s*. 6*d*. nett.)

The Geology of Devonshire. By W. A. E. Ussher, F.G.S. Victoria History of the Counties of England. Devonshire, vol. i, pp. 48. (London: Archibald Constable & Co., 1906.)

The Hills and Valleys of Torquay: A study in Valley-Development and an Explanation of Local Scenery. By A. J. Jukes-Browne, B.A., F.G.S. 8vo; pp. viii, 104, with 7 plates (pictorial views), and 12 maps and diagrams. (Torquay: published by the Author, Floriston, Torquay, 1907. Price 3*s*. 6*d*.)

TO those who have been accustomed to wield the hammer, there can be little doubt of the popularity and attraction of that branch of geology which deals with the sculpture of the earth's surface. The enjoyment of scenery must ever be enhanced by a knowledge of the leading facts in the physical geography of former geological periods, and of the earth-movements and erosions that have combined to bring about the present contours of the land. The difficulty is to make the subject attractive and intelligible to those who have given no attention whatever to geology.

The history of Devonshire scenery is probably as complex as that of any other region of similar extent, and Principal Clayden, in putting before his readers the results of long study on the subject, has taken the opportunity of dealing somewhat generally with the physical geography of England in past times. He goes back, in fact, to the very beginning ere he comes to treat of "the date when the history of Devon begins to be readable from its own records." This commences in the Devonian period, inasmuch as "The identification of the Morte slates as Silurian appears to rest on insufficient data." From Devonian we are taken on to Carboniferous times, and then to "the Great Upheaval," when the main features of disturbance in the palæozoic rocks were produced. A consideration of the Dartmoor granite and Exeter lavas gives occasion for a chapter on igneous rocks; and the description of the New Red sediments for a discussion of scree materials, alluvial fans, and desert conditions. The author takes us as far as the Church cliffs at Lyme Regis when he treats of the Lias; and in dealing with later formations up to the Chalk and its palæontological zones, he makes excursions to Purbeck and the Isle of Wight. The formation of "the Post-Cretaceous peneplain" is held to be different from that, described as "the Jurassic peneplain," beneath the Cretaceous rocks. In the words of the author, "The first was made by the advance of the sea modifying a land surface, the second by the retreat of the sea and the advance of land conditions over a sea bottom." Here we have still to deal with many difficult questions, concerning the age and origin of the earliest Tertiary strata in the district, and the earth-movements to which they were afterwards subjected. Comparing the Haldon gravels with those of the Bovey Basin, the author comments on the absence of Cretaceous strata beneath the beds at Bovey; while he argues that the Eocene beds of Haldon, which now rest on Upper Greensand, may have been accumulated on 200 feet of Chalk that has since been removed by solution. He suggests, indeed, that these Haldon beds may be older than the clays and lignites of Bovey, and coeval with London Clay or earlier Eocene. It is evident that we have still much to learn of the actual distribution of Eocene deposits on the Blackdown plateau, as at present they have not been clearly distinguished from purely local accumulations due to dissolution of the Chalk (clay-with-flints) and disintegration of Upper Greensand. Hence we feel inclined to await the results of further research before accepting the suggestion that "The Otter may thus be regarded as a former tributary of the Tone or of a magnified Parret flowing towards the [north-]east, while the Axe may have flowed direct into the head waters of the Dorset Frome."

The last ten pages of this volume are devoted to Modern Scenery, including uncovered Permian scenery, types of river erosion, and weathering of granite.

The author has given us a good outline of Devonshire geology, with sufficient information concerning the life-history of the successive periods to indicate the character of the physical conditions. He has, moreover, dealt with the successive epochs of erosion, deposition, and overlap, of depression and upheaval, which have resulted in the present form of the ground. If the plates giving restorations of ancient geography are 'ideal,' those picturing modern scenery and rock-structures are in nearly all cases excellent; and we can commend the book as one calculated to stir up interest and stimulate enquiry.

Mr. Ussher's account of the Geology of Devonshire is a lucid exposition of the general structure and palæontology of the county, to our knowledge of which he himself has so largely contributed. His work is accompanied by two admirable colour-printed maps, on which he has depicted the subdivisions he has personally made in the Carboniferous (three) and in the Devonian (eight). In dealing with the scenery he remarks: "There is no proof of the nature of the denudation of the palæozoic surface subsequent to the deposition of the Lower New Red beds, until the Cretaceous period. . . . . In this [transgression] and the subsequent deposition of the Eocene clays and gravels the older rock area was no doubt invaded, and the irregularities of its earlier contour planed and modified." The Bovey Basin, in his opinion, does "not appear to be due to local subsidences on fault lines, although the high dips of the sands on the south of the Bovey valley suggest such an explanation." He mentions that relics of deposits similar to Bovey Beds were noted by Mr. R. N. Worth on Plymouth Hoe, about 100 feet above O.D.; but he remarks that "The planed surfaces of the Devonian limestone hills of the Torquay, Brixham, and Plymouth area probably date from Permian times, as outliers of Lower New Red on the surface and in fissures are found near Waddeton and Brixham, etc."

Mr. Jukes-Browne's little book is one that deals with a limited tract of Devonshire, on which he has lived and laboured for some years. The object is to explain "the origin and gradual development of the physical features which contribute so largely to the popularity and attractiveness of Torquay." He has reproduced a portion of the Ordnance Survey map of 1809, with its graphic hill-shading, and he gives an interesting account of the original physical features of the neighbourhood of Torquay before it was much artificially modified. This description is further illustrated by the reproduction of a view from Castle Hill, sketched in 1824.

The author briefly points out the aims of geological investigation, and the agents to which the main forms of scenery are due, remarking "that a very little knowledge of geology will go a long way in explaining the origin of hills and valleys all over the world, as well as around Torquay in particular." This in view of what has been said before must be taken *cum grano.*

He gives an account of the many rock-types in the Devonian series; describes the Permian clay, conglomerate, and breccia in the district, and points out the disturbances and erosion that took place in the long interval between Permian and Eocene. To explain the development of scenery he has naturally to go beyond his immediate neighbourhood, inasmuch as "It is absolutely necessary to realize that when the existing valley-system was initiated no Devonian rocks were exposed in the Torquay district, but that these rocks were partly covered and concealed by the Permian conglomerate, and completely buried beneath the Eocene deposits to a depth of several hundred feet. Consequently the surface on which the modern lines of drainage were first marked out was a surface of Eocene clay or sand, having a gentle slope from north to south."

He speaks of great lateral pressures as taking place during the Miocene period, whereby the Eocene beds between Bovey and Newton Abbot were bent into a deep trough: a remark which may be compared with that of Mr. Ussher previously recorded.

Dealing with the process of valley-making, Mr. Jukes-Browne points out "how the water-ways, which were established on one surface, have been gradually transferred to a lower and very different surface." Much of this erosion took place during Oligocene, Miocene, and Pliocene periods, when the land-surface was, in his opinion, perhaps 1,000 or 1,100 feet above sea-level, and the present land was about 400 feet higher than it is now. Erosion may "have been retarded for a time in the Pliocene period by the subsidence which allowed of the formation of the St. Erth Beds in Cornwall. It must, however, have been renewed by the subsequent elevation of the land, and was only brought to a close by the subsidence which ushered in the epoch in which we now live."

The author deals in some detail with the development of the local hills and valleys, and explains how the denudation has revealed and dissected the old plains, the effects of Eocene, if not of the great Cretaceous erosion. His conclusions thus differ considerably from those of Mr. Alexander Somervail, who, in an essay read before the Devonshire Association in 1886, referred the sculpture of the main valleys in and around Torquay to the era "between the close of the Cretaceous period and the dawn of the Tertiary."

II.—Festschrift Harry Rosenbusch gewidmet von seinen Schuelern zum siebzigsten Geburtstag, 24 Juni, 1906. With a portrait, a geological map, 11 plates, and 35 figures in the text. 10″ × 7½″; pp. viii + 412. Stuttgart: Schweizerbart, 1906. M. 20 (unbound).

THIS volume, prepared by some of his students in commemoration of his 70th birthday, is dedicated to one of the most distinguished petrologists of the day. It contains 17 papers, all in German except those marked in the following notice by an asterisk, which are in English.

The first paper is by Prof. U. Grubenmann, of Zürich, "On some Swiss Glaucophane Rocks." He describes four glaucophane rocks of the Val de Bagne, Valais, and concludes that they are re-crystallized eruptive rocks of theralitic nature or their tuffs which were mixed with either calcareous or siliceous and aluminous material. Two erratic blocks from the canton of Bern have a similar character.

Prof. W. H. Hobbs (Michigan University), "On two new occurrences of the 'Cortlandt Series' of Rocks within the State of Connecticut." * The localities are Prospect Hill, near Litchfield, and Danbury to New

Fairfield. Prof. Hobbs concludes "that the generally rare gabbro, norite, peridotite, and pyroxenite types which most nearly correspond to the original 'Cortlandt Series' belong to a single magma which has here been intruded along the mutual borders of areas of granite, grano-diorite, and diorite, which may themselves have mingled to some extent; and that it has itself been later intruded by a fine-grained diorite. The extreme magmatic differentiation of this gabbroitic magma has been locally increased through the fusion with it of granite and grano-diorite."

Prof. E. A. Wülfing (of Kiel), "A Note on the Pigments of Minerals," describes experiments on the subject of the pigments in coloured minerals, leading to the important conclusion that pigments exercise no appreciable influence on the refraction of the minerals in which they occur.

Dr. C. Hlawatsch (of Vienna), "On the Amphibole of Cevadaes (Portugal)," describes an amphibole in the so-called arfvedsonite-gneiss of Cevadaes near Campo Mayor. It is intermediate in character to riebeckite and arfvedsonite, and Hlawatsch proposes to call it Osannite after Prof. A. Osann of Freiburg-i.-B.

Dr. E. O. Hovey (of New York), "The Geology of the Guaynopita District, Chihuahua: A contribution to the knowledge of the structure of the Western Sierra Madre of Mexico." * The oldest rock described is a semi-crystalline, much metamorphosed Cretaceous limestone, completely overturned and flexed in Guaynopita mountain. This folding was followed by the eruption of andesitic breccias, ash and flows, which are probably somewhat unconformable to the limestone; granite was then intruded, resulting in the completion of the elevation and metamorphism of the limestone; dacite, rhyolites, and basalt were afterwards extruded.

Prof. O. Mügge (of Königsberg), "The Rate of Decomposition of Quartz in the presence of Hydrofluoric Acid: A contribution to the Theory of Etched Figures."

Prof. L. Milch (of Breslau), "On Differentiation in Granitic Magmas from Observations on the Granite of the Riesengebirge."

Prof. M. Koch (of Berlin), "Note on the Olivine-diabases of the Upper Harz."

Dr. R. A. Daly (of Ottawa), "The Differentiation of a Secondary Magma through Gravitative Adjustment." * The paper describes the Moyie sill of hornblende-gabbro intrusive in quartzite in the Purcell Mountains, on the boundary between British Columbia and the United States. At the upper junction of the sill with the quartzite an abnormal biotite-granite is developed, which Daly attributes to digestion of quartzite in the hornblende-gabbro, at both the upper and lower contacts of the sill. He supposes the material digested at the lower contact to have mostly risen by gravitation through the whole thickness (840 metres) of the sill and accumulated at the upper contact.

Dr. E. Becker (of Heidelberg), "The Wartenberg near Geisingen in Baden." The columnar nepheline-melilite-basalt and associated eruptive breccia of the Wartenberg are allied to the other Swabian embryonic volcanoes (of Branco), and are to be regarded as filling a volcanic neck. The neighbouring Fürstenberg is believed to conceal a similar volcanic nucleus.

Prof. A. Osann (Freiburg-i.-B.), "On some Alkali-rocks from Spain," describes three rock-types. (1) A verite from Fortuna in the province of Murcia, previously described by Ramon Adán de Yarza as 'fortunite.' It is a glassy facies of (2) a rock termed by Yarza a trachyte, but which Osann proposes to call 'fortunite.' This fortunite (Osann) exhibits microscopically phenocrysts of almost colourless rhombic pyroxene, which is the only constituent to occur in two generations. It is accompanied in the groundmass by monoclinic pyroxene allied to diopside, phlogopite (mica), sanidine, apatite, ilmenite, and a not inconsiderable amount of glassy base. (3) The parent rock of the Jumilla apatites, which occur in veins traversing the volcanic rock. The rock is allied to the orendites of Whitman Cross, and Osann proposes to call it 'jumillite.' It is the first rock rich in leucite to be described as occurring in Spain.

C. Palache (Harvard University), "On Octahedrite, Brookite, and Titanite from Somerville, Massachusetts, U.S.A.,"* describes the occurrence of these titanium compounds in veins in diabase, from the alteration of the ilmenite in which he holds that they are derived. Twin structure [with (101) as twin plane] in octahedrite is recognized for the first time, and the alteration of brookite to sagenitic aggregates of rutile is recorded.

Dr. H. Preiswerk (Bâle), "Malchites and Vintlites in the Strona- and Sesia-gneiss (Piedmont)," describes two dykes of hornblende-malchite and one of mica-malchite at Lago Mergozzo, near Lag Maggiore, a dyke of diorite-porphyrite in Valle Canobbina and a vintlite (diorite-porphyrite) from a pass east of Gaby in Val Gressoney.

Prof. G. Steinmann (Freiburg-i.-B.), "The Origin of the Copper-ore Deposits of Corocoro and allied occurrences in Bolivia." The deposits described are limited to the inter-Andean plateau of the Bolivian Cordillera and occur in the Cretaceous Puca sandstone. The copper occurs chiefly in the metallic state. Prof. Steinmann regards it as a subsequent deposit. He believes it was contained in a solution in which sulphuretted hydrogen, sulphurous acid, and perhaps also carbon dioxide were the gaseous constituents. In order to obtain from such a solution metallic copper oxidising substances are requisite, and such are everywhere present in the sandstone, as iron oxide or hydrates. The sulphides of the solution will be oxidised, the sandstone will be bleached (as it is around the copper), the metal will be set free, and gypsum (usually present in the deposits) will be formed. Prof. Steinmann believes the ultimate source of the copper to be in the Tertiary Andes granites, diorites, and hypocrystalline porphyritic igneous rocks.

Dr. Th. Nicolau (Jassy), "The Aragonite of Sarul Dornei," describes needle-shaped crystals found in cavities of a sandy marl in Moldavia.

Dr. L. Finckh (Berlin), "The Rhomb-porphyries of Kilimanjaro," describes the rocks of Kilimanjaro previously described under other names by Prof. Bonney,[1] J. S. Hyland,[2] and Tenne.[3] They agree in essentials (except in bearing leucite) with the kenyites of Mount Kenya,[1] and belong to the family of trachy-dolerites. The phenocrysts consist of anorthoclase, olivine, nepheline, haüyne (scarce), magnetite, apatite, ilmenite, and zircon, and the groundmass, often more or less glassy, contains anorthoclase, olivine, nepheline, leucite, diopside, ægirine, ægirine-augite, låvenite (?), anomite, cossyrite (scarce), catophoritic hornblende. As secondary minerals, pseudobrookite, analcite, and other zeolites, calcite, and hyalite occur. According as nepheline or leucite predominates the rocks may be divided into Nepheline-rhomb-porphyries and Leucite-rhomb-porphyries.

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[1] Min. Mag., No. 32 (1886), pp. 10–12.

[2] Tschermak's Min. & Pet. Mitt., vol x (1888), p. 203.

[3] H. Meyer: "Ostafrikanische Gletscherfahrten," Leipzig, 1890, p. 305.

Dr. W. Wahl (Helsingfors, Finland), "On a Magnesium-diopside-bearing Diabase from Källsholm, Skärgård (skerry well) of Föglö, Aland Islands," describes a diabase containing a magnesium-diopside chemically very similar to that in the diabase of Richmond, Cape Colony, and the mixture of pyroxenes in the Hunne diabase of Halleberg (at the south end of Lake Vener in Sweden). The rock chemically resembles the olivine-diabase of Rhosson, near St. Davids,[2] and the Whin Sill[3] of Cauldron Snout.

Dr. Wahl's paper is the last in the volume, but owing to a mistake of the post-office a paper by Mr. A. C. Lane (State Geologist), of Lansing, Michigan, arrived too late for inclusion. It is entitled "Die Korngrösse der Auvergnosen" (the size of grain of the auvergnoses), and deals with the practical and theoretical conclusions which may be drawn from the microscopical study of the size of the constituents of igneous rocks, especially the quartz-diabase of the Medford dyke near Harvard University. The paper is published by Schweizerbart, Stuttgart, in the same style as the Festschrift.

B. Hobson.

III.—European Animals: their Geological History and Geographical Distribution. By R. F. Scharff, Ph.D., B.Sc., Swiney Lecturer on Geology. 8vo; pp. xiv and 258, with 70 illustrations. (London: Archibald Constable & Co., Ltd., 1907. 7*s.* 6*d.* net.)

THE most appropriate motto for the present volume would have been the author's own words quoted below, with the last sentence in italics, as we print it. "Our fossil evidence is of so very fragmentary a character that it is often extremely difficult to point to any particular country as the home of a species or genus. *The present distribution, however, may be looked upon as a reliable guide in directing our inquiries in this respect.*"

On the other hand, it would seem to us rather that "The present distribution must be looked upon frequently as a fallacious guide in directing our inquiries concerning the home of a species or genus."

Herein lies the one grievance we have with the contents of this otherwise excellent book. There is also in our opinion too much prominence given to migration, to marches and countermarches; and we must further disagree with the author where he assumes an extraordinary longevity of Mammalian species.

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[1] G. T. Prior: Min. Mag., vol. xiii (1903), p. 247.
[2] See A. Geikie: Quart. Journ. Geol. Soc., 1883, p. 303.
[3] Teall: Quart. Journ. Geol. Soc., 1884, p. 654.

We just spoke of *one* grievance, and here we have already pointed out three to begin with. The fact is, there exists a connection between these different matters; they can therefore be all summed up under one head. The present distribution, of course, depends more or less on migration (it is the divergence of opinion about the more or less which makes all the difference); and when the author assumes the possibility of a species (of Mammals) dating from the Tertiary, Pliocene, or Miocene, his conclusion is influenced by considerations taken from its present distribution.

What is 'geological history' of European animals? Just as the history of a nation is the account of the origin and evolution of that nation, so the history of European animals is, or ought to be, the account of the origin and evolution of European animals. By adding 'geological' to 'history' emphasis is laid on their origin and their past history generally. We are therefore led to assume that the author realises that biogeography cannot dispense with the teachings of palæontology. As a matter of fact, however, he has just told us that he can do without it. Pleistocene forms of life are frequently mentioned throughout the book, but Tertiary forms to a much lesser extent; since, however, the author frequently refrains from drawing any inferences from them they are generally little more than ornamental additions.

That our present fauna and flora are rooted in the past had already been acknowledged by Edward Forbes, who was far in advance of his time. Compare, for instance, his work, published in 1846, with Grisebach's "Vegetation der Erde" of 1872. Forbes, however, was a pre-Darwinian, and of necessity made use of pre-Darwinian language. When he recognises a Miocene element in the flora and fauna of the British Islands, his interpretation of the phenomenon is that Miocene plants and animals have been preserved to the present day without changing their specific identity. Migrations have to explain their survival with us, and to help generally over all other difficulties.

Dr. Scharff has taken Forbes for his model, but he apparently has not always kept in mind that modern biogeography, like modern systematic zoology and botany, cannot discard phylogenetic views. If you are opposed to these, it is best to say so, and to give the reason why; but you cannot ignore them.

On comparing the title of Dr. Scharff's book of eight years ago[1] with the title of the present one we should naturally expect to find in the latter more about the *geological* history of European animals than in the former; on comparing the contents, however, we discover that the opposite is the case. We ask ourselves if all this is done intentionally, if our author by chance wishes us to revert to Edward Forbes, i.e. to bring our present biogeographical work in consonance with the views of him who "has laid the foundations of a new method of research."

It is quite true that fossil evidence is often fragmentary; still, in the two groups from which the author draws the majority of his examples, snails and mammals, much work has been done in this direction.

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[1] "The History of the European Fauna," London, 1899.

In order to substantiate the grounds for our 'grievance,' we select and discuss a certain number of the author's illustrations which are to the point. Of the *beaver* it is stated (pp. 57–58) that, whilst now practically extinct in Western Europe, it is still plentiful in Russia and throughout Siberia. "We have here an example of an animal which evidently spread westward from the east, since it has never been found fossil in either Ireland, Italy, or Spain, where we should expect it to occur if it had originated in the west." About Ireland Dr. Scharff knows best. As regards Spain, it is dangerous to draw inferences from negative evidence in a country where so little is known of the Pleistocene fauna. With respect to Italy, no country of the world has yielded remains of beavers from so many different geological horizons as that country. They occur in the peat (Varese and elsewhere), in the interglacial lignites of Lecce, in the older Pleistocene of Arezzo, and lastly at least one species is known from the Upper Pliocene of the Val d'Arno. The latter is different specifically from the recent species, and the form from Arezzo has also been assigned to a distinct species. All are so nearly related that they were probably evolved from each other.

Our conclusions with regard to the distribution, past and present, of the mole (*Talpa europæa*) mentioned on the same page (p. 58) are very similar to that of the beaver. It would require pages to enter fully into the particulars of the case. The conclusions of the author are based in these instances upon incomplete and erroneous premises. What he says about the present distribution of the European mole is equivalent to stating that it has migrated from a region where it does not exist, and never existed for all we know, to one where it has existed since Pleistocene times. It appears to have escaped the author's observation that the mole of the Caucasian regions is different from the European; the Altai mole is still more dissimilar. On the other hand, nearly related forms are known from Southern Europe. As in the case of the beaver, we know the mole from European Pleistocene deposits, remains of a distinct species are known from the Pleistocene of Sardinia, and remains of Tertiary species have been found in various parts of Europe. There is therefore sufficient evidence to justify the assumption that *Talpa europæa* has been evolved in Europe.

In the fauna of the Spanish Peninsula "we have evidence of the existence of a very ancient endemic element" (p. 105). There is a North African fauna, too, in South Spain which is more recent than the endemic Lusitanian fauna. "The Lusitanian area was invaded by a North African fauna" (ib.), which itself is of old date, for "the African forms came to Spain in Miocene times."

It has hitherto been assumed—and in our opinion rightly—that the Spanish Peninsula owes the archaic elements of its fauna and flora to long isolation, a condition which must have rendered this region particularly unsuited to the rôle assigned to it on p. 100, of having been "a centre for distribution of species."

As regards the African forms in the recent Mammalian fauna of Spain, our knowledge of them, both in Spain and North Africa, is still imperfect. But this much may be asserted, when the author claims that these African forms came to Spain in Miocene times he commits a double heresy, namely, that they remained unaltered since the Miocene and remained so in two separate regions.

It ought to be clearly understood that no single living Mammalian species, Hyæna striata not excepted, existed so far back as the Pliocene.

Over and over again the well-established fact of the comparatively short duration of mammalian species is ignored by the author. For instance, on p. 221 we read: "The mammalian fauna of the North African Tertiary deposits has by no means been exhaustively examined, yet an extremely rich osteological collection has been brought together from Algeria. It has been shown that several kinds of hippopotamus, the rhinoceros, lion, buffalo, horse, wild ass, several antelopes, a camel, and many of the species which had been discovered at Pikermi, in Greece, had likewise lived in North-West Africa in the past, and had even persisted there up to Pleistocene times."

The mention of the Pikermi fauna, of which nothing is said when discussing the ancient land surface across the Ægean Sea, is quite out of place here; that the species found at Pikermi persisted to Pleistocene times is erroneous, and apt to lead to endless confusion. The Algerian deposits referred to are mostly Pleistocene or even alluvial; there is a doubt in some instances whether Upper Pliocene Mammals have been mistaken for Pleistocene, or *vice versâ.*

Arctomys.—We agree with the author that the Alpine fauna—as well as the Alpine flora—is of pre-Glacial origin, and that during the height of the Glacial period the Alps were not devoid of organic life. A species of marmot (*Arctomys*) has been found in Upper Pliocene deposits of Auvergne. From its extreme rarity it seems probable that the species did not live on the spot, but, like many of its extant relatives, was a dweller on mountains, and that its remains were only occasionally carried down by floods and entombed in lacustrine deposits.

Our author comments on the different species of the genus as follows:—"Like the chamois the Alpine marmot (*Arctomys marmotta*) is disseminated over several other European mountain ranges besides the Alps, and there is some fossil evidence of its having spread into the plains in Pleistocene times . . . . The Russian marmot (*Arctomys bobac*) formerly invaded the North European plain, and has since retreated to the eastern parts of our continent, whence it came. The Russian marmot is found right across Siberia as far as the Amur, and there are no less than ten other kinds of marmots in Asia. Asia is consequently the centre of distribution from which the marmots have radiated west and east, for five species have penetrated into Arctic North America. That this took place in pre-Glacial times is evidenced by the fact that one species is known from American Pliocene deposits" (p. 139).

We have just mentioned that a species is known also from European Pliocene deposits; the genus may already have been with us long before the Upper Pliocene. The recent discovery in the Oligocene of North America of a genus nearly related to *Arctomys* suggests that the latter may have been evolved in that continent, and *thence* spread east and west. The genus having existed in Western Europe *before* the Pleistocene, there is no stringent necessity for applying to Pleistocene migrations in order to explain its presence with us in that period. We have our doubts as to the soundness of the doctrine asserted by the author that a steppe fauna marched wholesale with flying colours into Central and Western Europe during post-Glacial times and marched back again. Several of the eastern steppe mammals—the bobak one of them—certainly extended formerly more to the west than they do at present; others of the supposed invaders prove one after the other, on closer examination, to be specifically distinct from eastern forms. The marmot found in a cave of Northern Germany (Gera) is closely related to the bobak, but still differs more from the latter than does e.g. the Turkestan marmot (*A. dichrous*, Büchn., *nec* Anders.). It is the same with the susliks. The most diffuse of our Pleistocene susliks is quite generally identified with the *Citellus rufescens* of the Ural Mountains, but it is likewise a distinct species.

The hopelessness of the undertaking to map out the islands and continents of a former epoch or of former epochs by the *existing* distribution of animals, to the exclusion of palæontological evidence, cannot be better illustrated than by the following passage: "If the opinion, expressed by several authorities, as to the extreme antiquity of the fauna of these islands [Sardinia and Corsica] should be substantiated, we could establish thereby the age of the European fauna as a whole. We should be able to discover the precise age of some of the animals inhabiting the British Islands. For in Sardinia and Corsica there occur such species as the field-mouse (*Mus sylvaticus*), which has a very wide European range and extends as far north as Iceland" (p. 215). From the context we gather that by "extreme antiquity" the Miocene is meant, for the author had just quoted Kobelt's contention "that these islands [Sardinia and Corsica] became separated from the continent in Miocene times, and that they were never since connected with it." He also refers to another malacologist's (Simroth's) suggestion of an immigration (in Corsica) in Miocene times. The author therefore implies that *Mus sylvaticus* may be a Miocene species! *Mus sylvaticus* occurs in fact in both islands, together with other mammals, which, with the exception of the Moufflon, are not represented in the Pleistocene deposits. The Pleistocene Mammalia of these islands, which the author does not discuss, point towards a continental connection in the Tertiary and their isolation at the end of that period. To explain the presence of the recent mammals we are therefore offered the following alternative. We must either adopt Dr. Scharff's suggestion that the recent Mammalian species, in spite of their absence from Pleistocene deposits, and in spite of their absolute identity with continental species, including small details in the coloration of their skin, already inhabited these islands in Tertiary times and have preserved their specific identity ever since. Or else we must accept the conclusion which has recently been arrived at, viz., that with the exception of the moufflon all the extant Mammalia of Corsica and Sardinia have been introduced by man, either intentionally or unintentionally. We think there can only be one opinion.

We have limited our criticisms almost exclusively to the rôle assigned by the author to the existing fauna, because that is the leading idea of the book. We have chosen the examples from the mammals for convenience sake, and because a great part of the work is devoted to this class by the author himself. We refrain from pointing out other matters in regard to which we disagree with the author; indeed, it is high time that we should speak of the excellent qualities of the book.

Everyone who has done work on similar subjects knows by experience how tedious it is to collect the necessary information whenever he has to travel outside his own department. In the present volume a prodigious amount of facts from many classes of the animal kingdom, with frequent references also to the flora, have been laboriously collected and discussed. In going over the bibliographical appendix we become aware that all the more recent publications on geographical distribution deal with but one or a few zoological subdivisions; so that Dr. Scharff's book is really an indispensable repertory of zoogeography, brought up to date. At the same time it loses nothing of its suggestiveness for advocating in some instances views whose accuracy is, in our opinion, open to discussion.

The numerous maps showing the distribution of single species or genera are exceedingly useful and instructive, many of them representing a vast amount of painstaking work. The hippopotamus (p. 78) shouting "Excelsior!" from the top of his mountain is both amusing and harmless.

On the whole it is a volume of great utility which we should be sorry to miss from our bookshelf. C. I. FORSYTH MAJOR.

IV.—THE GEOLOGY OF THE SOUTH WALES COALFIELD. Part IX: WEST GOWER AND THE COUNTRY AROUND PEMBREY. By Dr. A. STRAHAN, F.R.S., with notes by B. S. N. WILKINSON, T. C. CANTRILL, and E. E. L. DIXON. Memoirs of the Geological Survey. 1907. Price 8*d*.

THIS is an inexpensive explanation of an interesting tract in South Wales; the western half of the promontory of Gower with a part of the main coalfield between Llanelly and Pembrey. The advantage of a 'solid' as well as a 'drift' edition of the map is apparent. Placing the two sheets side by side, we can readily grasp the structural features of the country from the solid edition, but it would be a difficult matter to decipher this from the map which shows the greater portion of West Gower to be covered with Boulder-clay. For practical purposes both editions are equally necessary, and this fact is accentuated by the addition in the memoir of a valuable map of the unproved coalfield beneath the Loughor and Burry Estuary. The rocks described include the Silurian, Old Red Sandstone, Carboniferous, Trias, and Superficial deposits; and it is worthy of note that attention has been given to the zonal divisions in the Carboniferous Limestone Series. Among the Pleistocene phenomena, the Raised Beach, the Bone Caves, and the Glacial drift furnish interesting data which support the conclusion that the mammalia lived before the first manifestations of glacial action in South Wales.

V.—The Stone Implements of South Africa. By J. P. Johnson. 4to, cloth; pp. 53, with 258 illustrations. (London: Longmans, Green, & Co., 1907.)

IN this work the author embodies the results of his contributions, made during the last four years, to our knowledge of the Stone Age of South Africa. At the same time, while no attempt is made "to review the abundant, but unsatisfactory, literature already in existence," he makes mention of the work of many other observers.

He records the occurrence at Lejfontein of Eoliths belonging to two groups: (1) Those in which the pieces of stone have been subjected to very little modification; and (2) those in which they have been chipped into definite shapes. He reasonably observes that, if the Eoliths represent the earliest types of man's handiwork, "one would expect them to be barely distinguishable from Nature's work. Their association with others in which the trimming, though of the same rude kind, is arranged in definite patterns is the sole ground upon which they can be accepted." The illustrations include forms identical with many found in England.

Other implements from the Zambesi Valley in the vicinity of the Victoria Falls are described. Attention was first drawn to these by Colonel Feilden, and they have since been figured and described by Mr. G. W. Lamplugh (Journ. Anthrop. Inst., vol. xxxvi, 1906), who remarked that "many of the specimens show a secondary chipping which corresponds more nearly to rough European Neolithic work than to the earlier Palæolithic period." Mr. H. Balfour, who followed Mr. Lamplugh, described in the same journal a characteristic type of Palæolithic implement also from that region. Mr. Johnson regards many of his specimens as belonging to the transition between the Eolithic and Palæolithic stages of culture. He records typical Palæolithic implements from the deposits of the Vaal and Orange Rivers and elsewhere; and figures some minute flakes and scrapers, fashioned out of chert, jasper, and agate, from Taaibosch Spruit, a tributary of the Vaal, above Vereeniging, and from other localities. Newer or advanced types of implements are described from rock-shelters in the Asbestos Hills and elsewhere.

VI.—Maryland Geological Survey.

1.—The Pliocene and Pleistocene Deposits of Maryland. By George Burbank Shattuck. pp. 291, 75 plates, and 10 text-figures. (Baltimore: The John Hopkins' Press, 1906.)

THIS is the third of a series of reports on the systematic geology and palæontology of Maryland. The first and second volumes were devoted to the Eocene and Miocene deposits.

The Pliocene and Pleistocene formations of Maryland (as remarked by the State Geologist) have exercised a potent influence upon the surface configuration and soils of Maryland; and they are spoken of by the author as "the last of a long series of unconsolidated beds which began to be deposited in Lower Cretaceous and possibly Jurassic time, and have continued on with interruptions down to the present. These deposits are composed of clay, peat, greensand, marl, gravel, iron ores, and ice-borne boulders." The Pliocene deposits have yielded no fossils; on the other hand, those of Pleistocene age have yielded a diversified fauna and flora. The Mammalia are described by F. A. Lucas, the Reptilia by O. P. Hay, the Insecta by E. H. Sellards, the Crustacea, Mollusca, Cœlenterata, and Protozoa by W. B. Clark (State Geologist), the Molluscoidea by E. O. Ulrich, and the Plants by Arthur Hollick.

The volume is copiously illustrated with maps and diagram-sections, with photographic plates of scenery and geological phenomena, and figures of the organic remains. One plate gives a restoration of the American Mastodon, *Mammut americanum* (Kurr).

2. — REPORT ON THE PHYSICAL FEATURES OF MARYLAND. By WM. BULLOCK CLARK and EDWARD B. MATHEWS. pp. xv, 284, 30 plates, 19 text-figures, and geological map of Maryland. (Baltimore, 1906.)

This is in reality a handbook to the country, embracing an account of the physiography, geology, mineral resources, agriculture, climate, hydrography, terrestrial magnetism, and forestry. It summarises the information acquired, and will help to make popular the results of the Geological Survey. Among the illustrations are plates of characteristic fossils from Silurian to Pleistocene. The well-printed geological map shows clearly the various formations, and to the description of these are appended notes on the characters of the soils and the crops they yield.

VII.—IOWA GEOLOGICAL SURVEY.

WE have lately received the sixteenth volume of the publications of this Survey, including the Annual Report for 1905 and accompanying papers dated 1906. Under the direction of Dr. Frank A. Wilder, State Geologist, special attention has been given to economic geology; and he remarks: "There is a large and steadily increasing demand on the Survey made by residents of the State for assistance in investigating problems and examining specimens which seem to have economic significance. I have no doubt that in this the Survey at this stage in its development will render its greatest returns to the State, and the Director and his assistants have not hesitated to give freely of their time in answering appeals for examinations of mineral localities."

Reports on the geology of eight counties are included, together with statistics of the mineral production in Iowa for 1905. There was an increase in the production of coal, gypsum, and sand-lime brick.

VIII.—ALABAMA GEOLOGICAL SURVEY.

AN instructive report on "The Underground Water Resources of Alabama," by Mr. Eugene Allen Smith, has been published. As usual, there are introductory chapters on the physical geography, geology, and climate, and on the general principles of underground waters and artesian wells. These are followed by detailed descriptions of the wells, springs, and mineral waters of the country.

REPORTS AND PROCEEDINGS.

I.—Dorset Natural History and Antiquarian Field Club.

Under the guidance of Mr. W. H. Hudleston, F.R.S., an interesting and instructive excursion was made by sea to view the cliffs of the Isle of Purbeck and their continuation towards Weymouth. Leaving Swanage soon after midday on July 9th, the party embarked on board the steamer "Empress" and proceeded northwards towards the Foreland to examine the famous thrust-fault in the Chalk of Ballard Down. Returning thence to Swanage the downward sequence of strata was observed from the basal Chalk, through the Upper Greensand, Gault, and Lower Greensand of Punfield to the broad stretch of Wealden sands, coloured clays and lignites of Swanage Bay. Onwards by Swanage to Durlston Head the Purbeck Beds were well seen, based on the stronger Portland rocks which front the sea westwards to St. Ealdhelm's (St. Alban's) Head and Emmit Hill. Here, as the Director pointed out, we see the effects of an anticline which brings up the Kimeridge Clay, while the Portlandian escarpment commences to wind inland, and after producing the eminences of Hound-tout and Swyre Head, passes in a noble sweep through Smedmore Hill and Tyneham Cap into the final precipice of Gadcliff. Attention was drawn to the features of the Kimeridge Clay, its 'coal,' its ledges formed by cement-stone bands, and the numerous faults. Beyond Gadcliff the diversified features of the coast attracted much attention. Here the rampart of Jurassic rocks has been broken through, and the sea reaches the vertical Chalk in Worbarrow Bay; in Lulworth Cove, Man-of-War Cove, and other picturesque inlets, opportunity was taken to demonstrate the effects of denudation and of the remarkable disturbances to which the strata have been subjected. Westwards attention was drawn to the fine cliffs of Chalk and Upper Greensand of White Nothe, and the striking unconformity of Gault on the Purbeck, Portland Beds, and Kimeridge Clay below Holworth House. Thence to Weymouth lower strata were observed in the Corallian beds of Osmington and in the Oxford Clay which forms the low cliff north of the town. Thus ended a most enjoyable excursion in which the main features in the geology of Eastern Dorset, so grandly exhibited in the coast-sections, were viewed and explained under fairly favourable circumstances. About 120 members and their friends, including the President and all the executive, took part in it, and had the weather been less threatening the attendance would, no doubt, have been more numerous.

II.—Geological Society of London.

June 19th, 1907.—Aubrey Strahan, Sc.D., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "The Inferior Oolite and Contiguous Deposits of the Bath-Doulting District." By Linsdall Richardson, F.G.S.

In this paper a detailed description is given of the Inferior Oölite of the country between Doulting and Bath. The beds have been studied at different localities within the area by several geologists, but in most cases only the actual facts observable were recorded—there was little or no attempt at correlation. Now it is shown that there is within the area no Inferior Oolite deposit of earlier date than the Upper *Trigonia* Grit—a deposit of *Garantianæ* hemera. In the hills south of the Avon Valley at Bath, and as far south as a line drawn east and west through Carnicote, near Timsbury, this deposit rests upon the Midford Sands. South of this line, and between it and one similarly orientated about half a mile farther south, it rests upon the local Cephalopod Bed: here of greater antiquity than the 'Sands' (Midford); not younger, as in the case of the Cotteswold Cephalopod Bed. South of the latter line, the Upper *Trigonia* Grit, often conglomeratic, rests upon the non-arenaceous Liassic deposits, until in the more immediate neighbourhood of the Mendip Hills it is overstepped by the Doulting Stone, which rests directly upon the well-planed, bored, and oyster-strewn surface of the Rhætic White Lias and the Carboniferous Limestone. On the south side of the Mendip Hills the Upper *Trigonia* Grit comes in again.

The Fullers' Earth at Midford, at least the lower part, is of *zigzag* hemera. The intervening Inferior Oolite between it and the Upper *Trigonia* Grit may be thus divided, dated, and compared:—

Fullers' Earth			(*zigzag*).	
Inferior Oolite.	Doulting Beds.	I. Rubbly Beds.	(inter-*zigzag* *Truellii*.)	*Clypeus* Grit of the Mid and North Cotteswolds.
		II. *Anabacia* Limestones.		
		III. Doulting Stone.		
		IV. Upper Coral Bed	(*Truellii*)	= 'Coralline Beds' of Dundry.
		V. Dundry Freestone		(Usually absent.)
		VI. Upper *Trigonia* Grit	(*Garantianæ*).	
(Non-Sequence) Lias.				

In one appendix Mr. S. S. Buckman indicates the deposits in Dorset equivalent to the above; in another the late Mr. J. F. Walker and Mr. Richardson deal with the Brachiopoda of the Fullers' Earth, naming seven new species; and in a third, Mr. Richardson describes a new *Amberleya* and *Spirorbis*. The micro-fauna of the Upper Coral Bed is dealt with by Mr. C. Upton, who obtained from material furnished him from Midford and Timsbury Sleight most of the micro-Brachiopoda such as were found by Charles Moore at Dundry Hill.

2. "The Inferior Oolite and Contiguous Deposits of the District between the Rissingtons and Burford." By Linsdall Richardson, F.G.S.

This paper is presented with the preceding, because there are several points of similarity between the two districts described. Both are near lines of country along which movements of upheaval were frequent during the time of formation of the Inferior Oolite rocks.

In the Bath–Doulting district, above the Upper *Trigonia* Grit (which rests upon the Upper Lias) over a restricted area, is the Dundry Freestone, and over a greater the Upper Coral Bed. Then come the

Doulting Beds. The Doulting Beds are equivalent to the *Clypeus* Grit of the district here dealt with; the Rubbly Beds to the Rubbly Beds, and the *Anabacia* Limestones, *plus* the Doulting Stone, to the 'Massive Beds' of the *Clypeus* Grit. The basal portion of the Fullers' Earth in the neighbourhood of Midford is of *zigzag* hemera. There is no reason for assigning the thin clay-bed, with its median band of *Ostrea acuminata* Limestone at Great Rissington, to any other hemera. Whatever is the case elsewhere, there is no deposit in the Rissington district between the *Clypeus* Grit and the Fullers' Earth.

3. "The Flora of the Inferior Oolite of Brora (Sutherland)." By Miss M. C. Stopes, D.Sc., Ph.D., Lecturer in the Victoria University of Manchester. (Communicated by Professor J. W. Judd, C.B., F.R.S., F.G.S.)

This paper is to place on record the discovery of a bed containing impressions of plants, which represent a flora bearing a strong likeness to that of the Inferior Oolite of the Yorkshire coast. Previously, but one species and a second doubtful one were known from these coal-bearing beds. The bed in which the plants were found was a thin shale-band cropping out below high-tide level on the coast, about 1½ miles south of Brora. According to Professor Judd's mapping, this reef would come within the boundary of the Lower Oolite, although from the more recent Geological Survey map it appears to come in the position of the Middle Oolite. It forms a band 2 or 3 inches thick in a barren grey shale, and the impressions are fragmentary except in the case of *Ginkgo*, some of the leaves of which are practically perfect and show the veining of the lamina, and in some cases (after suitable treatment) the minute detail of the epidermis. Seven species of plants are identified, one of them being new, and four other species admitting of generic identification; and most of these species are identical with those obtained from the Inferior Oolite of Yorkshire. The minute structure of the leaves of *Ginkgo* is compared with those of *G. biloba*, and proves the species to be quite distinct. The plants found are those of a land-area, probably with firm ground surrounding pools or shallow water, as indicated by the fact that *Ginkgo* and *Equisetites* are the two commonest forms.

4. "The Constitution of the Interior of the Earth as revealed by Earthquakes (*second communication*): Some New Light on the Origin of the Oceans." By Richard Dixon Oldham, F.G.S.

The attempts which have been made to account for the oceans and continents are all subject to an uncertainty, in that we have had no means of knowing whether it is a mere irregularity of form that has to be accounted for, or whether this irregularity is but the expression of a deep-seated difference in the constitution of the earth. The paper is an attempt to clear up this uncertainty by a comparison of the European records of the San Francisco and Colombian earthquakes of April 18th and January 31st, 1906. In the former case the wave-paths to Europe lay under the continent of North America and the continental shelf of the North Atlantic, being typically continental in character; in the latter case they crossed the broadest and deepest part of the Atlantic basin, being essentially oceanic. The absolute rates of propagation cannot be compared, owing to the time of occurrence of the Colombian earthquake being unknown; but the interval between the arrival of the first and second phases is found to be longer in the case of this earthquake, by an amount much in excess of any probable error of record or interpretation. This difference indicates that the rate of propagation of the second-phase waves was relatively slower in the case of the Colombian earthquake, and, consequently, a difference in the constitution of the matter through which they were propagated. The Japanese records of the San Francisco earthquake also give an interval between the first and second phases which is greater than the average, the wave-paths in this case too being oceanic.

From these facts the general conclusion is drawn that oceans and continents are not mere surface irregularities of the earth's form, but are accompanied by, and probably related to, differences in the constitution of the earth beneath them, which extend to a depth of about one-quarter of the radius. It is not possible to state exactly in what this difference consists, beyond that it causes the rate of propagation of the second-phase waves to be less, in comparison with that of the first-phase waves, under the oceans than under the continents.

5. "The Swansea Earthquake of June 27th, 1906." By Charles Davison, Sc.D., F.G.S.

With the exception of the Hereford earthquake of 1896, the Swansea earthquake was the strongest which has been felt in this country for more than 20 years. It disturbed an area of 66,700 square miles, reaching from Rochdale on the north to Penzance on the south, and from beyond Maidenhead on the east to Waterford on the west. The centre of isoseismal 8 lies about 3 miles west of Swansea, the longer axis of the curve being directed E. 5° N. and W. 5° S. At Swansea, Neath, etc., the total number of chimneys thrown down or damaged must amount to several hundred.

The shock consisted of two distinct parts—the first part being much weaker than the second, except at places within an oval area lying some miles to the east of the Swansea epicentre. The existence of a secondary focus beneath this area is also indicated by the relative positions of the isoseismal lines, the isoseismal 8 being much nearer the isoseismal 7 at the western than at the eastern end. In twin earthquakes, it is difficult to ascertain the position of the focus in which the weaker impulse originated, but in the Swansea earthquake observations in mines offer an unexpected help. The shock was felt severely in mines within an area 8 or 9 miles in diameter, and as a tremor outside. The centre of this area lies about 1 mile west of Llwynypia, 22½ miles east of the Swansea epicentre, and is close to the centre of the area over which the weaker part of the shock was felt.

Observations, 53 in number, were obtained from 39 pits, distributed over an area 49 miles in length, from near Kidwelly to near Pontypool. The shock was, as usual, less strongly felt in pits than on the surface; and the sound was more uniform and monotonous underground. Both shock and sound were observed in pits over about the same area. In pits not more than 5 miles from the nearest epicentre, the sound seemed to pass below the workings; in those at a greater distance, it seemed as a rule to pass overhead or to travel along the workings. There is some, though not decisive, evidence for supposing that the fault was felt more severely in the lower than in the upper workings of a pit.

The originating fault in the neighbourhood of Swansea must run from E. 5° N. to W. 5° S., hading to the south, and passing not far from the line joining Llanelly to Neath, which is 5 or 6 miles to the north of the great east-and-west fault under Swansea Bay. The first movement occurred in the eastern focus near Llwynypia, and this was followed after a few seconds by a much stronger movement in the western or Swansea focus. The interval between the parts was such that the earlier impulse was felt first all over its disturbed area; but, as the foci were quite detached, the earthquake was no doubt a true twin earthquake.

6. "The Ochil Earthquakes of September, 1900, to April, 1907." By Charles Davison, Sc.D., F.G.S.

During this interval a series of slight shocks was felt chiefly in the villages of Blairlogie, Menstrie, Alva, and Tillicoultry, lying between the Ochil Hills and the river Forth. There were four shocks in 1900, one in 1903, ten in 1905, nineteen in 1906, and eight up to the end of April, 1907. The strongest shock of the series occurred on September 21st, 1905; its intensity was 6, and it disturbed an area of about 1,000 square miles. The originating fault must be directed from about E. 27° N. and W. 27° S., hading to the north, and passing not far from the villages mentioned above. It cannot, therefore, be identified with the great Ochil Fault, which in the district referred to runs from about E. 13° N. to W. 13° S. and near Dollar hades to the south; although it is possible that some or many of the slighter shocks may have been due to slips along this fault.

It was announced that "The History of the Geological Society of London," by Horace B. Woodward, F.R.S., illustrated with twenty-eight portraits and reproductions of medals, will shortly be obtainable at the Society's Apartments, price 7*s.* 6*d.* nett; and at the reduced price of 6*s.* by Fellows only.

The next Ordinary Evening Meeting of the Society will be held on Wednesday, November 6th, 1907.

III.—MINERALOGICAL SOCIETY.

Tuesday, June 11th.—Professor H. A. Miers, F.R.S., President, in the Chair.

Hamlinite from the Binnenthal, by Mr. H. L. Bowman. A mineral occurring in small brown six-sided plates in the white dolomite, to which the name bowmanite was given by Mr. Solly in 1904, is shown by analysis to be identical with hamlinite. The crystals show a division into six biaxial sectors, and are consequently pseudohexagonal.—Faceted Beads of Zinc, by Mr. T. V. Barker. The President described beads of zinc deposited on crucible lids by sublimation of zinc through oxide of tin. Some of these beads are covered with brilliant facets and present the appearance of crystals rich in faces. Mr. Barker has found that they do not lie in zones or obey the laws of distribution of ordinary crystal faces, and cannot therefore be regarded as the faces of a single crystal. There is, however, no evidence, from etching by acid, that the bead is an aggregate of crystals. The nature of these remarkable faces is difficult to understand. A bead of platinum presenting the same peculiarities was measured by the late Professor Miller. — Chlormanganokalite, by Dr. H. J. Johnston-Lavis and Mr. L. J. Spencer. A preliminary account of this new Vesuvian mineral was given by Dr. Johnston-Lavis in *Nature* on May 31, 1906. A new analysis of the mineral gives the formula $MnCl_2, 4KCl$. The crystals are rhombohedral, with a rhombohedral angle of 57° 36′; they are optically uniaxial with very weak positive birefringence; the refractive index is 1·59 and the specific gravity 2·31.—Mr. L. J. Spencer exhibited a suite of beautifully crystallized minerals, presented to the British Museum by Mr. Percy C. Tarbutt, from the Rhodesia Broken Hill mines in North-Western Rhodesia. In driving a tunnel through one of the kopjes, which consist mainly of cerussite and hemimorphite, a cavern containing flint implements and bones of recent mammals was encountered, and a cavity in the bone-breccia on the floor of this cave was encrusted with magnificent groups of hopeite crystals (the rare hydrous zinc phosphate discovered by Sir David Brewster in 1823). In the vicinity of the cave, crystals of another hydrous zinc phosphate were found in association with descloizite (hydrous vanadate of lead and zinc). The crystals of this new species, for which the name *tarbuttite* is proposed, are anorthic; they possess a perfect cleavage in one direction, through which emerges obliquely the acute negative bisectrix of the optic axes. Cavities in the ordinary ore are lined with large twinned crystals of water-clear cerussite, which are encrusted with small crystals of hemimorphite.—A group of quartz-crystals from British Guiana was exhibited by Mr. Anderson and a fine crystal of apatite by Mr. Gordon.

CORRESPONDENCE.

CHEMICAL REACTIONS BETWEEN SOLIDS.

Sir,—The attention of geologists should be drawn, I think, to some recent experiments by Mr. E. P. Perman, briefly described in *Nature* for June 20th last, in the abstracts of the Proceedings of the Royal Society; and of which further details will no doubt soon be available. The author finds that reactions take place between many pairs of salts in the solid state, but he also finds that careful drying prevents such reactions. From this he concludes that the reactions are carried on by means of thin films of water, acting as ionizing solvents. Many salts react on merely shaking their powders together; but all the changes are greatly aided and accelerated by heat and by pressure.

The importance of these experiments for geologists will be obvious enough, and needs no insisting upon, particularly in connection with metamorphic problems. Indeed, geologists might claim a sort of priority, for Mr. Perman's "Heat, Pressure, and Water" have been allies of ours for many years past. Not that this detracts from the value of such work to us. It is just such work that we need, to put our ideas into more distinct and scientific forms; and modern chemistry will evidently do this service more rapidly than we could have hoped. Mr. Perman's salts were no doubt more tractable than those that are the components of rocks, but then it is quite certain that his agencies have been applied to rocks fully in proportion to the refractoriness of their materials. And Adams's experiments upon the flow of marble show that some rocks, at any rate, are not beyond the power of laboratory treatment.

In this Magazine for May, 1903, I attempted to apply the work of Roberts-Austen on the Diffusion of Metals to the Diffusion of Granite into Crystalline Schists, and, at the close of my paper, I dwelt on difficulties arising from the heterogeneity of the materials of rocks. But it is clear that chemical reaction between solids adds vastly to the possibilities of solid diffusion unaided by such changes, and a hope of further information of the kind is expressed in the concluding paragraph of the paper quoted.

Geologists will look forward with interest to the full text of Mr. Perman's paper, and hope that he will pursue these researches further still. EDWARD GREENLY.

OBITUARY.

JOHN FRANCIS WALKER, M.A., F.L.S., F.I.C., F.C.S., F.G.S.

FORMERLY FELLOW OF SIDNEY SUSSEX COLLEGE, CAMBRIDGE.

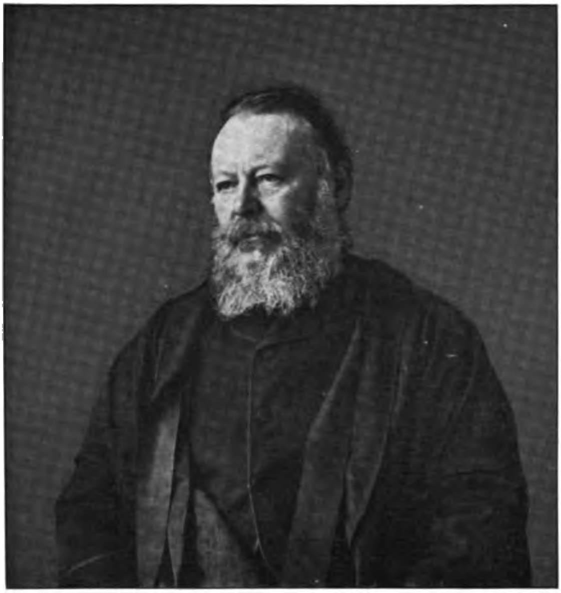
(WITH A PORTRAIT, PLATE XVI.)

BORN NOV. 25, 1839. DIED MAY 23, 1907.

ALL lovers of Yorkshire may well feel proud of the many eminent geologists who either claim it as their birthplace, or have adopted this grand county, so rich in geological and palæontological interests, as their home. One recalls to mind the names of some belonging to the past and some still present with us: Young and Bird, Dr. Wm. Smith, the Williamsons, Martin Simpson, W. Vernon Harcourt, John Phillips, Dr. H. C. Sorby, Dr. Murray, J. Leckenby, Sir Charles Strickland, Dr. John Lycett, Rev. Professor J. F. Blake, W. H. Hudleston, Dr. Reed of York, Professor L. C. Miall, Ralph Tate, Jas. Wm. Davis of Halifax, Dr. Tempest Anderson, Samuel Chadwick, G. W. Lamplugh, and many others. To those worthies whose names are inscribed upon her past records, must also now be added that of John Francis Walker.

Born at York, Nov. 25th, 1839, J. F. Walker was, by inheritance, a Freeman of that city, where his family had resided for several generations, his grandfather having held the office of Sheriff in 1841. At an early age he commenced his education at St. Peter's School, York, and at 18 he became a student at the Royal Agricultural College, Cirencester, where under Dr. Voelcker, F.R.S., Professor of Chemistry, and Professor James Buckman, F.G.S., Professor of Natural History, he imbibed that earnest love of chemistry and geology which had such an important influence on his future career in life. In 1862 he entered Sidney Sussex College, Cambridge, and was bracketed first in the Natural Science Tripos in 1866. From Cambridge, after taking

GEOL. MAG. 1907. Plate XVI.



J F Walker

his degree, Mr. Walker proceeded to the University of Bonn, where he studied organic chemistry under Professor Keckule, and remained in Germany during the Franco-Prussian War. Returning to London, John Francis Walker studied Law, and was in due course called to the Bar, but never practised.

He subsequently returned to Cambridge as Chemical Lecturer, and was elected to a Fellowship in Sidney Sussex College, where he had formerly been a student. But even his love for chemistry was in time entirely overshadowed by his stronger attachment to geology.

In 1867 he was elected a Fellow of the Geological Society, and in 1873 of the Linnean Society. About this time he also became a Fellow of the Chemical Society, and a member of the Geologists' Association.

J. F. Walker took the deepest interest in collecting the fossils from the Lower Greensand of Cambridgeshire, known generally as the "Coprolite Workings," and on May 7th, 1867, he communicated his first paper to the Yorkshire Philosophical Society on "Some new Coprolite Workings in the Fens" (Geol. Mag., Vol. IV, p. 309), and later on in the same year another paper, "On some New Terebratulidæ from Upware" (Geol. Mag., Vol. IV, p. 454, Pl. XIX).

In 1882 Mr. Walker married Miss Alice Cracknell, of Knowle House, Ealing, W., and afterwards retiring from Cambridge he settled at 45, Bootham, York, devoting the greater part of his time to his geological pursuits.

During his residence in York, for the last 25 years, John Francis Walker has taken the deepest interest in the prosperity of the Yorkshire Philosophical Society's Museum, and has been for some time past its senior Vice-President and Honorary Curator of its Geological Collection, to which he has also been a most liberal donor.

He presented the types of his Cambridge Greensand Brachiopoda to the British Museum, and those illustrating his joint paper with Mr. G. W. Lamplugh, "On the Brachiopoda from the Lower Greensand of Leighton Buzzard, Bedfordshire," to the Geological Society's Museum.

Mr. S. S. Buckman, F.G.S., writes to the Editor:—"The loss of our friend and fellow-worker in geology, John Francis Walker, will be keenly regretted by all who are interested in the study of Brachiopoda. They will miss a genial friend who was ever ready with kind sympathy and practical help. He had accumulated a splendid collection of British and foreign Brachiopoda; and he would place his knowledge and his specimens at the disposal of other students with the greatest generosity. Many anecdotes are told of his readiness to help. If an investigator wished to examine certain specimens from a Yorkshire locality and Mr. Walker had not a sufficiently good series, he would take the trouble to make a special visit to the locality in order to obtain the necessary material. Or a student wishing to compare some foreign species with its British allies, made application to Mr. Walker. If he possessed specimens they were placed at the student's disposal; but on occasions when he had not any examples he has sent to the Continent to purchase them, and has desired the student to keep one of the best for his own collection. Spontaneously, too, he enriched many a cabinet. A box of specimens would arrive with a kindly note to say that he had obtained an interesting series from some locality, and he hoped his correspondent would find the enclosed specimens an addition to his series.

"Although Mr. Walker collected Brachiopoda of all ages and all countries, he perhaps paid most attention to British Jurassic species. He was the first to find the rare *Dictyothyris* [*Terebratula*] *Morieri* in England, and one of his earliest papers gave an account of the discovery. For many years he spent some portion of the Summer on the Dorset coast to work the rich deposits in the neighbourhood of Bridport; and he published some papers on his discoveries in this district. He also made sojourns in the Cotteswolds; while at other times his hammer was busy among the rocks of Yorkshire. Only last Summer he made a collecting tour among the Jurassic rocks of the Normandy coast, and several of his friends' cabinets are the richer for specimens which he then obtained. All who have had the good fortune to join Mr. Walker in his geological excursions will feel the keenest regret that they will no more hear his cheery voice, or be able to share his great enthusiasm over the discovery of some fine specimen."

One of his most attached Yorkshire friends, Mr. G. W. Lamplugh, F.R.S., writes:—"Placidly and unobtrusively, he stood aside to let the turmoil pass him, and only those who were privileged long to enjoy his friendship—to be among whom I count myself fortunate—could appreciate the depth of his knowledge and of his kindliness.

"In his palæontological studies his aim was toward an ideal thoroughness that perhaps is unattainable, and he was always content—even, as it seemed to me, too content—to wait for conditions that should approach his ideal. Thus, much work of excellent purport that he contemplated, and might have done well, because it could not be done perfectly remained undone to the end. Although his collection of the Mesozoic Brachiopoda—his favourite and lifelong study—was probably the most extensive that has ever been made, his saying was always—'We want more material! We must wait till we have sufficient material!' And it was his philosophical grasp of the broader problems of his subject that led him to this attitude, and not merely the spirit of the collector. The fundamental principle of his method found expression in his favourite dictum: 'It would be good for palæontology if all type-specimens should be destroyed!'—and most workers who have striven to follow the recent developments of palæontological science will apprehend the truth that underlies this paradox. Walker, firmly holding the evolutionary idea to which his work had led him, recognized that 'the true type of a species is its centre, where the individuals are most thickly clustered and most closely resemble each other,' and that 'a named figured specimen is only a fixed point' which may, or may not, happen to be near or within the central cluster of the species. Hence, he said, no single individual can adequately represent a species, and the so-called species based on type-specimens are of unequal value and often misleading.

"These ideas were expressed baldly and without specific demonstration in his brief paper 'On the Formation of a Species,' published in the GEOLOGICAL MAGAZINE for January, 1905 (Dec. V, Vol. II, pp. 15–17); but no one unacquainted with the worker can have guessed from it how huge was the store of exact observation that underlay this apparently sporadic expression of opinion.

"Walker's quiet enthusiasm in a task that appealed to him was well exemplified by the manner in which he followed up the discovery of a fossiliferous band rich in Brachiopoda at the top of the Lower Greensand near Leighton Buzzard, which enlisted his attention five years ago. During two successive summers he spent many days on the spot, accumulating material and educating the workpeople in the collection of specimens. Not only the quarrymen but also the children of the quarrymen became his willing helpers, and will long remember his kind and generous presence among them. His aim was to acquire the whole of the Brachiopoda that could be obtained from the limited nodular band that yielded the fossils, with the idea that it would give him the opportunity at last for amassing sufficient material to deal adequately with the question of 'species' and their relation to 'varieties.' Some preliminary results of his work were published, not very willingly on his part, in our joint paper in the Quarterly Journal of the Geological Society for May, 1903 (vol. lix, pp. 234–265, pls. xvi–xviii), based on a collection that would have been already too large for the patience of most palæontologists, though the refrain to his specific descriptions in this paper is still 'the want of further material.' His subsequent accumulation of the specimens went steadily on, until he could number them by hundreds or thousands, all laboriously cleaned, measured, and sorted, into their proper specific relationship, ready for the final work to be done. And, a short time ago, when I wrote to tell him that a recent visit to the section led me to think that the calcareous lenticles had been practically all removed in quarrying, so that he must not hope for a fuller series of the fossils, he replied cheerily that this could not be quite so, as he had just received a fresh parcel from the quarrymen that added to our knowledge.

"But now, by the sad event of his short illness and untimely death, we are reminded once more that no single life is long enough for the completion of such work, and that fragmentary instalments alone are possible to us. For the task unfinished there is indeed in his case this slight consolation, that the concrete material which he so patiently collected and brought into order lies ready for the future student to take up the arrested work. So that not only by what he himself achieved, but also by the achievement that he has made possible for the workers who will follow him, the name of John Francis Walker will be remembered and honoured.

"The loss to palæontological science is severe. But still more severe is the loss, to us who knew him, of an ever-genial, broad-minded, big-hearted friend."

Mr. Linsdall Richardson writes to the Editor:—"To geologists like myself Mr. Walker was chiefly known as a keen Brachiopodist. The writings of the late Dr. Thomas Davidson, F.R.S., in the Palæontographical Society's volumes, show that he was in frequent communication with that eminent palæontologist. Of his extensive collections, that of Brachiopoda was perhaps one of the best in the world. His kindness was proverbial, and he was ever ready, by the gift of specimens and the loan of literature, to assist anyone who was working at his favourite subject, and often took much trouble and expense to meet the requirements of his many friends and correspondents. At the time of his death Mr. Walker had been a Fellow of the Geological Society for forty years. His latest piece of Brachiopod work, upon which, indeed, he was elaborating at the time of his death, related to the Fullers' Earth Brachiopoda, more especially to those from the Bath–Doulting district, and was to have been a joint communication with the writer to the Geological Society."[1]

He leaves a widow and one son, Mr. Gelson Walker, to deplore his loss.

The following is a list of Mr. J. F. Walker's published papers:—

1866. "On the Fossils contained in a Lower Greensand deposit of Phosphatic Nodules in Bedfordshire": Ann. Mag. Nat. Hist., vol. xviii, pp. 31–32, 381–386.

1867. "A Reply to Mr. H. G. Seeley's Remarks on my account of the Phosphatic Deposit at Potton, in Bedfordshire": ibid., vol. xx, pp. 118–122.

"On some new Coprolite Workings in the Fens": Geol. Mag., Vol. IV, pp. 309–310.

"On some new Terebratulidæ from Upware": Geol. Mag., Vol. IV, pp. 454–456.

1868. "On a new Phosphatic Deposit near Upware, Cambridgeshire": Geol. Mag., Vol. V, pp. 26–27.

"On the Species of Brachiopoda which occur in the Lower Greensand at Upware": Geol. Mag., Vol. V, pp. 399–407.

"Occurrence of *Terebratula* (*Waldheimia*) *pseudo-jurensis* (Leymerie) in England": Ann. Mag. Nat. Hist., n.s., vol. i, p. 386.

"On the Occurrence of the genus *Anser* in the peat and gravel deposits in Cambridgeshire": ibid., vol. ii, p. 388.

1870. [Letter on] "Fossil Insects in the Bournemouth Leaf-Bed": Geol. Mag., Vol. VII, p. 299.

"*Rhynchonella* from Bradford Clay": Proc. Yorks Nat. Club, 1869; Geol. Mag., Vol. VII, p. 299.

"On Secondary Species of Brachiopoda": Geol. Mag., Vol. VII, pp. 560–564.

1876. "New British Brachiopoda": Geol. Mag., Dec. II, Vol. III, p. 574.

(With W. H. Hudleston.) "On the Distribution of the Brachiopoda in the Oolitic Strata of Yorkshire": Rep. Yorks Phil. Soc., pp. 7–12.

1878. "On the Occurrence of *Terebratula Morieri* in England": Geol. Mag., Dec. II, Vol. V, pp. 552–556.

1888. "On the Spinose *Rhynchonellæ* (genus *Acanthothyris*, d'Orbigny) found in England" (in conjunction with S. S. Buckman): Yorks Phil. Soc. Rep.

"On *Terebratula bisinuata*, Lam., from the London Clay of Hampshire"; Yorks Phil. Soc. Rep.

"On Oolitic Brachiopoda new to Yorkshire": Yorks Phil. Soc. Rep.

1892. "The Discovery of *Terebratulina substriata*, Schlotheim, in Yorkshire": Geol. Mag., Dec. III, Vol. IX, p. 364.

"On Liassic Sections near Bridport, Dorsetshire": Geol. Mag., Dec. III, Vol. IX, pp. 437–443.

"On Yorkshire Thecidea": Geol. Mag., Dec. III, Vol. IX, p. 548.

1903. "On a Fossiliferous Band at the top of the Lower Greensand near Leighton Buzzard, Bedfordshire": Quart. Journ. Geol. Soc., vol. lix, pp. 234–265.

1905. "On the Formation of a Species": Geol. Mag., Dec. V, Vol. II, pp. 15–17.

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[1] See Abstract of Proceedings, Geol. Soc. of London, June 19, 1907, *ante*, pp. 374–5.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE V. VOL. IV.

No. IX.—SEPTEMBER, 1907.

ORIGINAL ARTICLES.

I.—THE CENTENARY OF THE GEOLOGICAL SOCIETY OF LONDON.

IN January last we referred to the celebrations in honour of this important event.[1] We have now the pleasure to call attention to the "History of the Geological Society of London,"[2] a work which has been written by Mr. Horace B. Woodward, F.R.S., F.G.S., in commemoration of the Centenary. Mr. Woodward has had the help of Mr. H. W. Monckton, Treasurer, who has described the Medals of the Society, Mr. R. S. Herries, M.A., V.P., who supplies a correct version of the Charter, and Professor E. J. Garwood, M.A., Secretary, who undertook to deal with illustrations. Sir A. Geikie, K.C.B., President, Professor Watts, F.R.S., Secretary, Professor Bonney, F.R.S., and Dr. H. Woodward have assisted by reading the proofs, but they are "not responsible for any individual statements" except where expressly acknowledged. These and other persons are duly thanked for the help afforded.

The result of Mr. Woodward's laborious researches has been the production of a book of the greatest possible interest, and one which should be read, not merely by the Fellows of the Geological Society, but by all geologists interested in the history of their science. It is a record of first-class importance, and is, on the whole, a fair and accurate account of the events which have occurred in the Geological Society up to 1860, for the later years are perhaps too fresh in the memories of many to allow of that pleasing view obtained by distance.

Opening with a rapid sketch of the histories of academies and learned societies before 1800 and a note on early geological researches in England, the author refers to the Askesian Society, which, founded in 1796, became the parent of the British Mineralogical Society in 1799. Amalgamating in 1806, these two Societies apparently threw off a "Geological Dinner Club" on 13th November, 1807, which club consisted of the following thirteen members:—Arthur Aikin (1773–1854), William Allen (1770–1843), William Babington (1750–1833),

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[1] Arranged to take place at Burlington House, London, commencing on Thursday, September 26th, and ending September 30th, 1907, under the presidency of Sir A. Geikie, K.C.B., F.R.S.

[2] "The History of the Geological Society of London," by Horace B. Woodward, F.R.S. 8vo; pp. 336, with 23 portraits and 5 illustrations of medals awarded by the Society. (London: published by the Geological Society, Burlington House, August, 1907. Price 7*s.* 6*d.*; to Fellows, 6*s.*)

Jacques Louis Comte de Bournon (1751–1825), Humphry Davy (1778–1829), James Franck (–1843), George Bellas Greenough (1778–1855), Richard Knight (–1844), James Laird (–1840), James Parkinson (–1824), William Hasledine Pepys (1775–1856), Richard Phillips (1778–1851), and William Phillips (1773–1828). It was resolved at this meeting (particulars of which are to be found in the first Minute Book of the Society):—

> "That there be forthwith instituted a Geological Society, for the purpose of making geologists acquainted with each other, of stimulating their zeal, of inducing them to adopt one nomenclature, of facilitating the communication of new facts, and of ascertaining what is known in their science, and what yet remains to be discovered.
>
> "That the gentlemen present, with Mr. Pepys and Mr. William Phillips, who have been prevented from attending this meeting, be considered the first members of the Geological Society.
>
> "That henceforth members be chosen by ballot. Any person desirous of becoming a member, having communicated his wish through the Secretary to the Society, without being proposed or recommended in any other manner, shall be balloted for at the next meeting. The election to be unanimous.
>
> "That no person resident in London attend more than two meetings of the Society without becoming a member.
>
> "That each member shall be at liberty to introduce a visitor, under the preceding regulation.
>
> "That the Society dine together, at the Freemasons' Tavern, on the first Friday of every month, from November to June inclusive, at 15*s.* per head, visitors to pay as well as members. Dinner to be on the table at five o'clock precisely. Fine for non-attendance 10*s.* 6*d.* Any member may avoid this fine by sending notice to the Secretary of his intention to be absent, three days before the meeting.
>
> "That at the last meeting in June a subscription be raised to defray incidental expenses incurred by the Treasurer for the purposes of the Society.
>
> "That G. B. Greenough, Esq., M.P., be treasurer, and Dr. Laird secretary, for the ensuing year.
>
> "That a book be provided for recording the minutes of the Society and for the insertion, by members and visitors, of any geological intelligence that may be presented. Every communication must be signed by the person who makes it.
>
> "(Signed) G. B. GREENOUGH."

The meetings of the Society and its Committees appear to have been held in a room temporarily engaged at the Freemasons Tavern. The Society thus began its existence much in the form of a geological dining club, a feature which gradually disappeared. Moreover, the system of fines was not a success, for in June, 1809, it was announced that though the fines amounted to £37 16*s.*, £6 16*s.* 6*d.* only had hitherto been received.

On December 4th, 1807, the Right Hon. C. F. Greville was invited to become the patron, Mr. Greenough was elected the first president, and Mr. W.H. Pepys became treasurer. It was also decided that forty-two persons be elected honorary members of the Society, and these seem to have been chosen from all parts of the British Islands, and to have included such men as Richard Bright of Bristol, Joseph Carne of Penzance, J. J. Conybeare and John Kidd of Oxford, E. D. Clarke and John Hailstone of Cambridge, Robert Jameson and John Playfair of Edinburgh, Richard Kirwan of Dublin, and others.

An extraordinary omission occurs in this list of names, that of William Smith, and it is recorded by John Phillips that Smith was "almost unnoticed, except by visits from Mr. Greenough, the president, Sir James Hall, and a few other members to examine his collections in Buckingham Street (March, 1808)."

The first communications brought before the Society were by Mr. Knight, who recorded his results obtained from melting Rowley Rag, and by Count Bournon, who showed specimens illustrative of the varieties of compact felspar.

Two Vice-Presidents were added on January 1st, 1808, and on the same day a Committee appointed to draw up the regulations of the Society presented its statement, which was adopted. As early as April, 1808, a Committee was formed "to examine papers *previously* to their being read to the Society, and to take charge of all presents that may be received."

The first printed "List of Members" bears date 1808, and in 1809 rooms were engaged, in the name of Leonard Horner, on the ground floor at No. 4, Garden Court, Temple, for the reception of its cabinet and for the meetings of the Committees.

In 1809 a "Plan for consolidating the Geological with the Royal Society as an Assistant Society" was proposed. This plan seemed not so much an attempt at consolidation as at suppression, for it proposes that "the subscribing members who are Fellows of the Royal Society shall constitute the first class or Council of the Geological Society, and be invested with the power of electing members or making byelaws," etc., while "the Royal Society may select such papers as it may please to read at its table and to print in the *Philosophical Transactions*," and such other papers may either be deposited in the collection of the Geological Society or included in any publication which it may think proper to undertake at its own charge. This plan was very properly dismissed by resolution "That the propositions communicated from the Right Hon. Charles Greville, having a direct tendency to render this Society dependent upon, and subservient to, the Royal Society, are inadmissible."

In March, 1809, the foundation of the present magnificent library was commenced, and by November the specimens in the Museum had been arranged geographically.

In 1810 more extensive premises were obtained at 3, Lincoln's Inn Fields; in the same year trustees were appointed, and it was decided that cards recording the dates of the meetings be printed and sent to each member prior to the commencement of the session. A Council was also formed, and held its first meeting on July 14th, 1810.

The first volume of the publications of the Society, called *Transactions*, appeared in 1811, and this and the successive volumes are remarkable, not only for the classical papers they contain, but for the wealth of illustration. The *Proceedings* followed in 1827 as a method of communicating more rapidly to the Fellows the affairs of the Society, and these were incorporated in the well-known *Quarterly Journal* in 1845; while the present form of *Abstracts of Proceedings* dates from May 20th, 1857, although they have been technically *published* only since 1905.

Perhaps the most important publication issued by the Society was Greenough's "Geological Map of England." This he commenced in 1808, knowing quite well of the existence of William Smith's map (published in 1815) and being largely indebted to it for the completion of his own. It cost £1,300, of which £200 went to Webster for drawing, £111 19*s.* 9*d.* for copperplates, £914 10*s.* 3*d.* to Neele for engraving, and £73 10*s.* for paper. It was issued by Messrs. Longman, Rees, & Co. at £6 6*s.* in six sheets with a memoir, and members were allowed to purchase it for £5 5*s.*

An unofficial dining club was started in 1824 and has existed to the present day; it is limited to forty members, who dine together before proceeding to the meetings. A charter of incorporation was obtained from H.M. King George IV on April 23rd, 1825, and the title 'Fellow' became fixed by the members being so designated in this document. This charter cost £385 14*s.* 6*d.*, and Babbage calculated how much the 'F.G.S.' cost each Fellow per letter.

In 1828 the Society obtained rooms in Somerset House from the Lords Commissioners of His Majesty's Treasury, through the mediation of the President and Council of the Royal Society, and the apartments so allowed to them were adapted to their purposes by Decimus Burton, who was a Fellow of the Society. Here the Society remained until 1874, when the Government transferred the accommodation to the present Burlington House, Piccadilly, where the Society, it is hoped, has found a permanent home.

W. H. Fitton seems to have been the first president whose annual address was printed, in 1827, and since that year, with the single exception of Warburton, the Presidents have delivered an annual address, dealing either with the progress of the science, or, a few notable exceptions, with some new matter distinguished by its brilliancy of thought and its originality.

Such, then, is in brief the history of the Geological Society of London, so ably set forth by Mr. Woodward in this volume. But not content with this history, Mr. Woodward has woven around his central story a general sketch of English geology wherever and whenever it comes in contact with the Geological Society. We learn the outlines of the troubles between Murchison and Sedgwick, and the extraordinary action of the Society with regard to Sedgwick; the difficulties with Beete Jukes, and Searles Wood, and Charles Moore, and the troubles of the woman question. We have presented to us an account of the Ordnance and Geological Surveys, the colouring of geological maps, the Museum of Practical Geology, catalogues of fossils, early collectors, and the cataloguing of geological literature. We see the figures of the old giants rise before us, and meet again with Lyell, Macculloch, Phillips, Mantell, Scrope, 'King' Cole, De la Beche, and scores of others, of whom many anecdotes are recorded, and of some of whom excellent portraits are given. We read afresh the old discussion on Buckland's famous memoir on the Evidences of Glaciers in Scotland, based on Agassiz' observations; we hear that caustic remark of Owen when he referred to Falconer as "that distinguished *botanist*"; and we long to possess that letter of Sedgwick's addressed to Murchison in 1853 which ended "Ever (whether in peace or war) your affectionate old friend, A. Sedgwick." We attempt to picture the size of John Miller, who had to make a rush for the door of the four-wheeler in order to get through; we hear the chuckle of Professor Lapworth when he had written "The Secret of the Highlands"; and we decide not to devote ourselves to rock classifications.

So far as this history is concerned it is fairly fully dealt with up to 1860, but after that date exigencies of space and other considerations have necessitated brief treatment. The volume has a good coloured reproduction of Buckland, carrying his well-known bag, for frontispiece; while portraits are given of Babington, Greenough, William Phillips, Macculloch, W. D. Conybeare, Sedgwick, Murchison, Fitton, Scrope, Lyell, William Smith, De la Beche, Godwin-Austen, John Phillips, Mantell, Falconer, E. Forbes, Prestwich, Jukes, Ramsay, Blanford, and A. Geikie. Most of these are excellent, but what effect John Phillips would now make if he marched down Piccadilly in those trousers it is difficult to imagine. Illustrations of all the medals awarded by the Society are given, and the volume closes with lists of the early members, lists of the staff, and others, and an efficient index. It reflects high credit on the author, and on the Society. We thank both, and congratulate Mr. Woodward on a labour of love happily conceived and admirably carried out.—S.

II.—NOTE ON TWO RARE FORMS OF *ACTINOCAMAX* FROM THE ENGLISH UPPER CHALK.

By G. C. CRICK, A.R.S.M., F.G.S., of the British Museum (Natural History).

THE present note relates to two specimens. One was obtained by Mr. G. E. Dibley, F.G.S., from the *Micraster cor-anguinum* zone of the Chalk at Gravesend, and now forms part of the British Museum collection (register number C. 10576); the other is in the collection of Dr. H. P. Blackmore, F.G.S., of Salisbury (to whom I am indebted for the loan of the fossil), and was obtained from West Harnham, near Salisbury, at the base of the zone of *Actinocamax quadratus*. Being the more nearly perfect, the Salisbury specimen is described first.

ACTINOCAMAX BLACKMOREI, n.sp.

Description.—The specimen (Fig. 1), which is almost perfect, is 94 mm. long, and has a smooth surface; it is fusiform, and has its greatest thickness at a point which is a little nearer the posterior than the anterior end. Here the guard is depressed, its dorso-ventral and transverse diameters being 13·75 and 15 mm. respectively. From this point the guard tapers evenly and slowly towards the anterior end, and evenly and slowly towards the posterior end, but shortly before the extremity is reached it contracts somewhat rapidly, and forms a fairly acute, almost mucronated point; the extreme tip, however, is wanting. Sponge-borings can be plainly seen beneath the surface. Viewed laterally the ventral and dorsal surfaces of the anterior three-fifths of the guard are nearly parallel, the dorsal surface in this view appearing to be nearly straight and the ventral feebly swollen. Whilst the greater part of the guard is depressed, the anterior fifth is decidedly compressed. The truncated anterior surface is flat and almost at right-angles to the axis of the guard; it is oval, its ventro-dorsal and transverse diameters being 11·5 and 10·5 mm. respectively, the greatest width being a little nearer the ventral than the dorsal surface. There are no traces either of a ventral fissure or of the alveolus. The dorso-lateral grooves are well-preserved; at the anterior end of the fossil they are rather broad, flattened, very slightly concave, about 6 mm. apart, and each about 4 mm. wide; proceeding from this end each narrows rather rapidly for about 28 mm., being then only about 2 mm. wide; the two grooves separate rather quickly from each other for about one-half the length of the specimen; they are then continued nearly parallel to each other over another fourth of the length of the guard, when they gradually disappear.

Measurements.

	mm.
Length	94
Dorso-ventral diameter at the most inflated part	13·75
Transverse diameter at ditto	15
Dorso-ventral diameter at anterior end	11·5
Transverse diameter at ditto	10·5

Affinities and differences.—In a dorsal aspect the specimen bears some resemblance to M. Janet's figure (fig. 5*a*) of the dorsal surface of *Actinocamax Alfridi*,[1] but that species is more lanceolate and has the posterior portion of its guard less inflated than the present specimen; whilst in a lateral aspect the anterior half of the guard of this specimen tapers less rapidly than in that species. Compared with M. Janet's figures of *Actinocamax Grossouvrei*,[2] the present

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[1] Bull. Soc. géol. France, sér. III, tom. xix, No. 9 (Nov., 1891), pp. 720, 721, pl. xiv, fig. 5, and text-fig. 4. M. Janet does not give the dimensions of the single specimen upon which he based the species, but, taken from his figures, they are as follows:—Length, 96 mm.; dorso-ventral diameter at the most inflated part, 14 mm.; transverse diameter at ditto, 15 mm.; dorso-ventral diameter at the narrowest part, which is at about the level of the ovisac, 9 mm.; transverse diameter at ditto, 8 mm.

[2] Bull. Soc. géol. France, sér. III, tom. xix, No. 9 (Nov., 1891), pp. 716–719, pl. xiv, figs. 1–3, and text-figs. 2, 3. For the sake of comparison with the forms described in the present paper, the dimensions of M. Janet's co-types of *Actinocamax Grossouvrei* are here given:—

	I.	II.	III.
Length in millimetres	97 (?)	97	91
Dorso-ventral diameter at the most inflated part	16	14	13
Transverse diameter at the most inflated part	20	18	15
Dorso-ventral diameter at the narrowest part, nearly at the level of the ovisac	14	8	8
Transverse diameter at the same place	17	12	9

To this species M. de Grossouvre ("Recherches sur la craie supérieure," pt. i, fasc. 2, 1901, pp. 796 and 801) refers the unique specimen which M. Janet described and figured in the same paper (ibid., pp. 719, 720, pl. xiv, fig. 4, and text-fig. 1) as *Actinocamax Toucasi*, the two forms being, according to M. de Grossouvre, extreme modifications of the same type and connected by a number of intermediate links. The dimensions of the holotype of M. Janet's *A. Toucasi* are:—Length, 90 mm.; dorso-ventral diameter at the most inflated part, 12 mm.; transverse diameter at the most inflated part, 17 mm.; dorso-ventral diameter at the narrowest part at the alveolar extremity, 5 mm.; transverse diameter at the same place, 6 mm. Both forms occur at the same horizon as *Actinocamax granulatus* and *Actinocamax verus*; in France in strata which French authors regard as Upper Santonian and Lower Campanian (M. de Grossouvre, loc. cit.). It is interesting to note that two similar modifications of this species have been recorded (as *Actinocamax* specimen bears some resemblance to that author's figures 3*a*, *b*, but it is less inflated posteriorly and tapers less rapidly anteriorly than

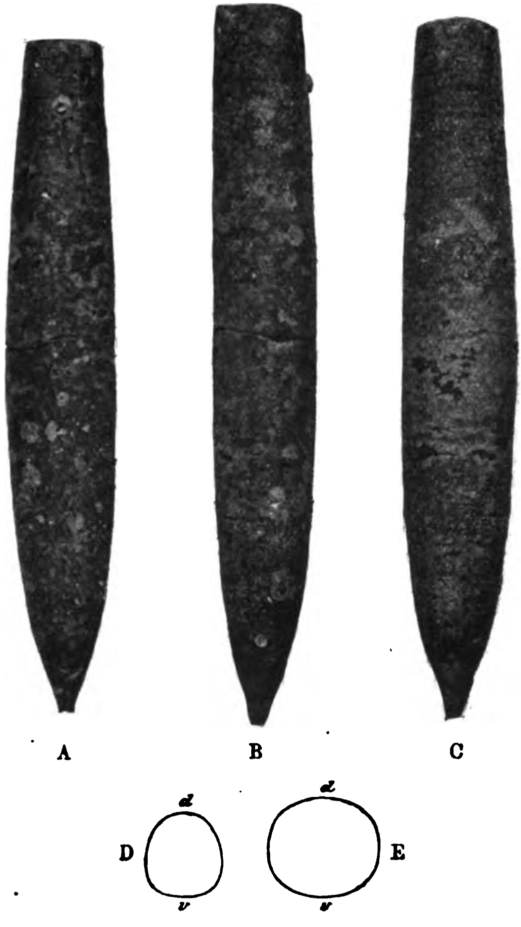

FIG. 1.—ACTINOCAMAX BLACKMOREI, n.sp.
Upper Chalk (Senonian, base of zone of *Actinocamax quadratus*), West Harnham, Salisbury. (Dr. H. P. Blackmore coll.)

A.—Ventral aspect.
B.—Right lateral aspect, showing the flatness of the dorsal surface and the slight inflation of the ventral surface.
C.—Dorsal aspect, showing the dorso-lateral grooves.
D.—Sectional view of alveolar end: *d*, dorsal; *v*, ventral.
E.—Transverse section at the most inflated part of the guard: *d*, dorsal; *v*, ventral.
All the figures are of about the natural size.

depressus [= *A. Grossouvrei*] and *A. depressus*, var. *fusiformis* [= *A. Toucasi*]) associated together in the Cretaceous rocks in the north of Germany (Professor Dr. A. Andreae, "Ein neuer *Actinocamax* aus der Quadratenkreide von Braunschweig"; Mittheil. aus dem Roemer-Museum Hildesheim, No. 2, Dec., 1885).

the original of those figures; the compressed form of the alveolar end of the present example serves, however, to distinguish it from *Actinocamax Grossouvrei*. The fossil appears to be intermediate between *Actinocamax Alfridi* and *Actinocamax Grossouvrei*, but it does not appear to be identical with any described form of the genus. The present writer has therefore great pleasure in naming the species after Dr. H. P. Blackmore, F.G.S., of Salisbury.

Horizon and locality.—Dr. Blackmore's specimen was obtained from the chalk-pit at West Harnham, near Salisbury, at the base of the zone of *Actinocamax quadratus*. It is from a somewhat higher horizon than the Gravesend specimen which is described below.

ACTINOCAMAX sp.

Description.—The specimen (Fig. 2) consists of about two-thirds of the length of the guard, the posterior third being entirely wanting.

The anterior end is much fractured, especially on the ventral side, so that there is no trace of a ventral fissure if such existed, but a small piece of the dorsal part of the alveolar border is preserved; this seems to show that originally the alveolar end was only slightly excavated; before being imbedded in the chalk mud, however, this end was somewhat deeply excavated, but this excavation evidently did not form part of the original alveolar end, as is clearly shown by the angle at which the side of this cavity meets the small piece of the smooth original alveolar surface which is preserved. The sides of this cavity are also very irregular and covered with small pyramidal masses of a fibrous crystalline material (calcite), so that it is quite clear that they did not constitute the sides of the alveolus,[1] these latter being smooth and having precisely the same angle of inclination as the sides of the phragmocone. Nor does the cavity appear to have been that not infrequently produced in some forms of *Actinocamax* owing to the decay, after the death of the animal, of the uncalcified portion of the guard immediately surrounding the phragmocone.[2] Doubtless the central portion of this end of the guard was very imperfectly calcified, and was therefore easily disintegrated after the guard became detached from the animal. That the guard was exposed to the action of the sea for some time after the death of the creature is clear from the numerous sponge-borings by which it is traversed. Owing to the fractured condition of the anterior end, the dimensions of this part of the guard can best be taken at about 10 mm. below the alveolar border; here the transverse section of the guard is oval, the ventro-dorsal and transverse diameters being 12 and 10·5 mm. respectively, and the greatest width at a distance of about one-third of the ventro-dorsal diameter from the ventral surface.

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[1] The term 'alveolus' is frequently somewhat loosely applied. The 'alveolus' is really the conical cavity at the proximal end of the guard of a typical Belemnite into which the phragmocone fits. Usually, however, in the genus *Actinocamax* the portion of the guard immediately in contact with the sides of the phragmocone was not calcified, and during fossilisation was destroyed; when, therefore, a conical cavity is preserved in the genus its sides are not those of the 'alveolus,' but those of a cavity having a greater angle than the 'alveolus.'

[2] See figures of the alveolar end of various forms of *Actinocamax* in the GEOL. MAG., 1904, p. 409.

The posterior end is abruptly truncated at right angles to the axis of the guard, its ventro-dorsal and transverse diameters being 10 and 12·5 mm. respectively. The most inflated part of the guard is at a distance of 54 mm. from the alveolar extremity, and therefore only about 16 mm. from the posterior truncated end; the ventro-dorsal and transverse diameters here are 12 and 13·5 mm. respectively. It will thus be seen that in a ventral aspect the fossil has its greatest diameter at a point about three-fourths of its length from the alveolar end, and that from this point it tapers rather rapidly towards the alveolar end, but in the opposite direction only very slightly between this point and its posterior truncated end; whilst in a lateral aspect the dorsal and ventral surfaces are as nearly as possible parallel to each other. Anteriorly the fossil is compressed, whilst posteriorly it is depressed. The dorso-lateral grooves are well marked, and at about 6 mm. below the alveolar border are only about 3 mm. apart; in passing backwards they separate rather rapidly from each other until reaching the most inflated part of the guard, when they converge slightly over the rest of the specimen. Anteriorly each groove is flattened, broad, with its lateral boundary obscurely defined, and decreases in width rather rapidly until reaching the most inflated part of the guard, where it becomes relatively narrow (about 2 mm. wide) and parallel-sided. The ventral surface of the posterior half of the guard is flattened. The surface of the guard is smooth, but on the ventral portion of the most inflated part of the guard it is somewhat uneven, suggesting that here there is a slight deformation.

Certain grooves and sharply-incised lines near the posterior end of the guard are evidently the marks of injury. Thus, on the ventral surface and towards the right side (see Fig. 2, A), and having its median line about 4 mm. from the posterior end, there is a transverse roughened groove about 7 mm. long and 4 mm. wide, as if produced by a serrated edge. Also, on the right side and near the dorsal surface, there is another similar groove (see Fig. 2, D), about 7 mm. long, 2 mm. wide, and 2 mm. from the posterior end, whilst at some 3 mm. above this there is a shallower and much less regular groove of about the same length. Again, on the left side (see Fig. 2, C) and near the dorsal area, the surface extending upwards from almost close to the posterior fractured end for a distance of about 11 mm., and over a width of about 10 mm., bears a number of short, irregular, finely-incised lines.

As already stated, the fossil is imperfect at each end; the fracture at the alveolar end is comparatively recent, and was probably produced during, or possibly subsequent to, the extraction of the specimen from the rock. The fracture at the posterior end seems, however, to have been produced before the specimen was imbedded in the chalk, and most probably at the death of the animal. The marks near the posterior end that have been alluded to above seem to have been caused by the teeth of some animal, an enemy of the Belemnite, the saw-like cuts being produced by two adjacent teeth, and the sharply-incised lines by the point of the tooth placed in opposition to these two, for it is to be observed that the sharply-incised lines are as nearly as possible opposite the space between the two series of jagged saw-like cuts. As these marks are not quite at the extremity of the specimen, the guard does not appear to have been bitten through, but rather to have broken off short during the Belemnite's struggles to escape. That the animal did not long survive the injury seems evident from the fact that the edges of the fractured surface are still fairly sharp; had the creature lived long after the guard was fractured these edges would doubtless have been more or less rounded off by the more or less enveloping mantle.

Measurements.

	mm.
Length	70+
Dorso-ventral diameter at the most inflated part	12
Transverse diameter at ditto	13·5
Dorso-ventral diameter near anterior end ...	12
Transverse diameter near ditto	10·5

Affinities and differences.—In a dorsal aspect the specimen agrees fairly well with M. Janet's figure (fig. 5*a*) of the dorsal surface of *Actinocamax Alfridi*,[1] but in a lateral aspect the dorsal and ventral surfaces are much more nearly parallel than are indicated in that author's fig. 5*c*. Again, the transverse section at the most inflated part of the guard is markedly depressed and not so nearly circular as in *Actinocamax Alfridi*. The depressed form of the transverse section of the posterior part of the guard agrees more closely with M. Janet's figures of *Actinocamax Grossouvrei*,[2] but the guard in that species is not so lanceolate, and has its anterior end depressed instead of compressed; further, in a lateral aspect its alveolar end tapers much more rapidly than that of the present specimen. Like the form described above, the present specimen seems to be intermediate between *Actinocamax Alfridi* and *A. Grossouvrei*; and it also is not identical with any described form of the genus known to the present writer. Compared with *Actinocamax Blackmorei* described above, the present example exhibits several differences, which may or may not prove to be of importance. The specimen is more slender, and when viewed ventrally is relatively less inflated at its broadest part; its ventral surface is flatter; the transverse section at its broadest part is relatively more depressed; and, in a lateral view, this specimen tapers evenly and slowly from the anterior end backwards, whilst in the same aspect *A. Blackmorei* is a little inflated at about the middle of the guard. Owing to its imperfection the writer, however, has not ventured to name this fossil.

Horizon and locality.—This specimen was obtained by Mr. G. E. Dibley, F.G.S., from the *Micraster cor-anguinum* zone of the Chalk in Messrs. Fletcher & Co.'s pit at Gravesend. It is the specimen which, in his paper "On the Zonal Features of the Chalk-pits in the Rochester, Gravesend, and Croydon Areas," Mr. Dibley records[3] from this pit as *Actinocamax*, n.sp.; amongst other fossils recorded from the same pit being *Actinocamax verus* and *Actinocamax Merceyi*

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[1] Bull. Soc. géol. France, sér. III, tom. xix, No. 9 (Nov., 1891), pp. 720, 721, pl. xiv, fig. 5, and text-fig. 4.

[2] Ibid., pp. 716–719, pl. xiv, figs. 1–3, and text-figs. 2, 3.

[3] Proc. Geol. Assoc., vol. xvi, pt. 9 (August, 1900), p. 495.

[=*Actinocamax granulatus*]. Thus from the list of associated fossils it will be seen that this specimen occurs at the same horizon as *Actinocamax Grossouvrei.*

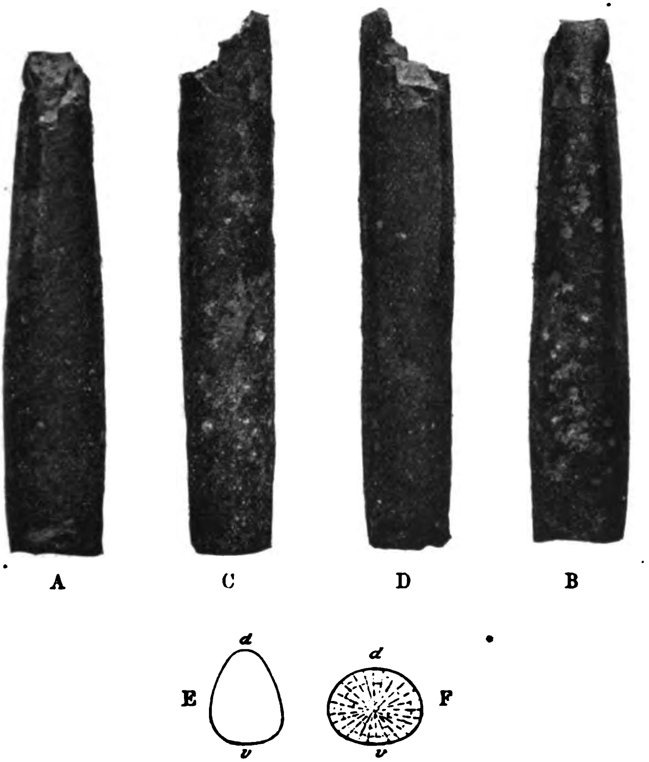


Fig. 2.—Actinocamax sp.

Upper Chalk (Senonian, zone of *Micraster cor-anguinum*), Gravesend, Kent. (British Museum collection, register number C. 10576.)

A.—Ventral aspect, showing one of the jagged saw-like cuts near the posterior end.

B.—Dorsal aspect, showing the dorso-lateral grooves, and very imperfectly near the posterior end two jagged saw-like cuts on the right. There are a number of irregular sharply-incised lines on the left near the posterior end, but these do not appear in the Figure.

C.—Left lateral aspect. The irregular sharply-incised lines near the posterior end seen in this view are scarcely visible in the Figure.

D.—Right lateral aspect, showing jagged saw-like cuts near the posterior end, two on the left and one on the right.

E.—View of the truncated posterior end: *d*, dorsal; *v*, ventral.

F.—Sectional view near alveolar end: *d*, dorsal; *v*, ventral.

All the figures are of about the natural size.

III.—SEDGWICK MUSEUM NOTES.

A NEW SPECIES OF *LICHAS*.

By F. R. COWPER REED, M.A., F.G.S.

(PLATE XVII.)

LICHAS (HOMOLICHAS) MELMERBIENSIS, sp. nov.

IT is rarely the case that we find complete individuals of any species of *Lichas*, especially in the Ordovician rocks, but several entire specimens belonging to a new British species have been recently collected by Mr. V. M. Turnbull from the Dufton Shales near Melmerby, and detached head-shields, pygidia, and hypostomes from the same locality and horizon are not uncommon. Since most species of *Lichas* have been founded on detached and isolated portions of the body, it is desirable to give a somewhat full description of this new form, which belongs to a group of the genus not previously recognised with certainty in the British Isles.

Description.—Body oval, flattened, narrowing somewhat posteriorly, about two-thirds as wide as long. Head-shield broadly transverse and semilunate, measuring about 2½ times as wide as long; lateral angles produced backwards and overlapping outer portions of the first 4 or 5 thoracic pleuræ; median portion of head-shield projecting abruptly, interrupting regularity of anterior curved outline at anterior lateral angles of glabella.

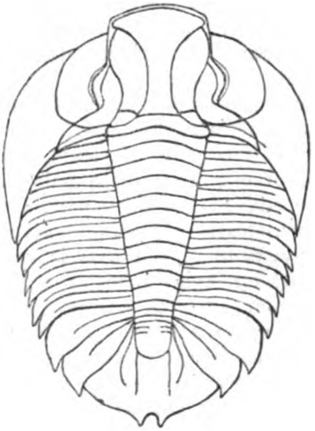
Glabella, fixed cheeks, and inner portion of free cheeks form prominent swollen central mass, raised high above flattened outer portion of free cheeks, which are much produced backwards into large pointed genal angles and extend nearly to the middle of the thorax.

Glabella somewhat oblong in shape, rather longer than wide, the axial furrows being subparallel with a slight outward concavity. The glabella is curved down more or less strongly in front of its middle, but is flattened from side to side. It consists of a median lobe with a long narrow neck, and is completely defined by the backward prolongation of the first lateral furrows to the occipital furrow, as in typical members of the section *Homolichas*. The median lobe has a frontal width equal to more than twice the width of the neck, and the triangular lateral angles completely extend in front of and overlap the anterior ends of the tricomposite lateral lobes. A slight widening of the neck of the median lobe takes place towards its base, owing to the divergence posteriorly of the prolonged first lateral furrows, but the median portion of the neck has nearly parallel sides.

Tricomposite lateral lobes elongated-oval, somewhat pointed anteriorly, slightly curved outwards in front and less so at their base, towards which they narrow a little, but their axes are nearly parallel. Their base is rather abruptly truncated by the strong furrows which cut off the pair of rather large triangular or subrhomboidal occipital lobes, and are regarded as the displaced lateral portions of the occipital furrow. These occipital lobes are completely circumscribed, but are rather less swollen than the lateral lobes of the glabella.

First lateral furrows of uniform strength for their whole length and completely marking off the median lobe of the glabella; they converge at first strongly inwards, then curve backwards and run almost parallel on each side of the neck, curving again a little outwards before meeting the occipital furrow, which they do at an angle of about 70° or rather less. The axial furrows curve gently outwards round the front end of the lateral lobes, then bend slightly inwards, describing a weak concave curve in their course to the occipital lobes, outside which they bend strongly outwards.

The occipital furrow consists of a median straight portion at the base of the median lobe of the glabella, and the paired lateral portions displaced rather forwards, which enter the axial furrow at right angles. The occipital ring is broad, flattened, and somewhat arched forwards, with the two oblique lateral furrows cutting off the occipital lobes; there is no distinct median tubercle.



Restored outline figure of *Lichas* (*Homolichas*) *melmerbiensis*, sp. nov.: Dufton Shales, near Melmerby.

Fixed cheeks small, reniform, convex, about half the length of the glabella, and about two-thirds the width of the lateral lobes, along which they extend to a point rather in front of their middle. The posterior part of the fixed cheek bends strongly outwards behind the eye, and extends for less than half the distance between the axial furrow and the lateral margin of the head-shield. The eye-lobe is flattened and separated off by a distinct shallow furrow, which is weakly angulated in the middle.

Free cheeks consisting of an inner swollen portion, which rises up suddenly almost to the level of the glabella and nearly overhangs the front margin, and of an outer lateral portion, which is depressed, weakly convex, and triangular, and is prolonged backwards into the large pointed genal angles. Eyes semilunate, narrow, about one-third the length of the glabella, and are supported on the swollen portion of free cheeks.

The head-shield is ornamented with rather widely spaced, round tubercles, of moderate and fairly uniform size, between which are scattered smaller secondary and tertiary ones without any regular arrangement and usually at some distance apart.

Thorax of eleven segments, not decreasing much in width posteriorly. The axis, however, which is strongly convex and prominent, is conical in shape, tapering rather rapidly towards the pygidium to half its anterior diameter. The ornamentation of the axis consists of small sharp tubercles of fairly equal size, not closely placed nor regularly disposed, with a few smaller ones interspersed. The axial furrows are strong.

The pleuræ are of uniform size and overlap slightly; their inner half is arched up gently, while their outer half bends down slightly and curves backward to end in a falcate point. Each pleura bears on its feebly convex surface a well-marked submedian and slightly diagonal furrow, which dies out shortly before reaching the point. The tubercles, which are like those on the axis, are usually arranged in a single row of widely spaced primary ones alternating with a double row of secondary or tertiary ones along each side of the diagonal furrow.

Pygidium of rather a transverse shape, not quite twice as broad as long, with a convex axis of less than one-fourth the total width and lateral lobes composed of two pairs of complete pleuræ ending in free marginal points, and of one incomplete pair followed by a median postaxial piece. The ends of the third pair of pleuræ form a pair of short blunt projections, closely placed, and give a bifurcate posterior termination to the pygidium. .The axis is prominent, convex, and subcylindrical; the strong axial furrows scarcely converge at all posteriorly and are prolonged with undiminished strength nearly as far behind it, but do not reach the posterior margin. The axis extends for about half the length of the pygidium, and its convexity is continued into the anterior portion of the post-axial piece, dying out rather suddenly. A weak curved furrow (sometimes interrupted in the middle) crosses over this median convexity and defines the axis behind, the axial furrows bending in slightly at this point on each side. There are 2 to 3 complete well-marked rings on the front end of the axis followed by traces of 1 to 2 fainter incomplete rings. Each pleura of the first pair on the lateral lobes has a subfalcate shape and is curved gently backwards beyond the weak fulcrum, ending in a short free recurved point; a submedian diagonal furrow traverses about two-thirds of its length, and is inclined at about 15° to the front edge of the pygidium.

The second pleura is separated from the first by a slightly sinuous furrow nearly parallel to the diagonal furrow of the first pleura. This pleura is more leaf-shaped and has a narrow base; its end forms a short recurved free point like the first, and its surface bears a diagonal furrow nearer the anterior than the posterior margin of the pleura and parallel to the first interpleural furrow. The interpleural furrow between the second and third pleura makes an angle of about 45° with the axial furrow. As stated above, the third pleura is incomplete, not being marked off from the post-axial piece by a complete furrow to the margin. This pleura is broad and triangular, and bears a submedian furrow on its surface curving round inwards towards the prolongation of the axial furrow, but dying out before reaching it. Half the side of the pygidium is formed by the margin from the second pleura to the point of the third pleura, and it is weakly sigmoidal, bending at first outwards and then inwards. The points of the third pair of pleuræ are somewhat closely placed, and the margin between them is rather deeply emarginate. The post-axial piece is nearly as wide as the axis, is flattened, and bears no furrow. The tuberculation of the pygidium is similar to that of the thorax, but the tubercles show no regularity of distribution on the pleuræ, and the general surface of the lateral lobes seems to be also very finely granulose.

The hypostome associated with this *Lichas* and most probably belonging to it has a strongly arched anterior outline and a deeply and broadly emarginate wide posterior border, but only the body is well preserved in any case. The body is rounded-subquadrate, moderately convex, rather broader than long; anteriorly it has a strongly arched outline, but its sides are subparallel, and its posterior end is abruptly truncated nearly at right angles and almost straight The lateral middle furrows form a pair of simple broad, short, rather oblique notches in its sides at about two-thirds its length, and do not fork.

Dimensions:

	I.	II.	III.	IV.	V.
Length of whole individual	31·75	30·00	—	—	—
Length of head	9·50	9·00	—	—	—
Width of ditto	27·00	27·00	—	—	—
Width of glabella at base	7·25	—	—	—	—
Length of thorax	13·25	11·75	12·00	—	—
Width of thoracic axis at front end...	9·00	8·00	7·75	—	—
Length of pygidium	9·00	9·00	8·50	15·5	—
Width of ditto	20·50	20·00	16·00	26·0	—
Width of axis of ditto	4·00	4·00	3·50	6·0	—
Length of hypostome	—	—	—	—	11·25
Length of body of ditto	—	—	—	—	6·75

Affinities.—The general characters of the head-shield ally this form very closely to *L. angusta*, Beyr.,[1] which Schmidt says is distinguished from *L. deflexa*,[2] Sjogr., by the glabella being less swollen and the median lobe less transversely expanded in front. The pygidium of *L. angusta*, so far as it is known, agrees more with *L. Eichwaldi*, according to Schmidt, than with our specimens. The latter resemble in this part *L. deflexa*, which has the points of the third pair of pleuræ on the lateral lobes similarly projecting; but in ours these points are closer together, the whole pygidium is less transverse, the second pair of pleuræ do not extend so far back, and the diagonal furrows of the third pair do not unite with the axial furrows. The hypostome of *L. angusta* seems to be practically identical, so far as ours is known.

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[1] Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. ii (1885), p. 108, t. iv, figs. 18–23.

[2] Ibid., p. 101, t. iv, figs. 24–35.

L. Eichwaldi, Nieszk.,[1] and *L. Pahleni*, Schmidt,[2] are also closely allied to our Melmerby form.

In *L. Eichwaldi* the inner portion of the free cheeks is similarly swollen and the outer portion depressed, and the median portion of the head-shield projects in the same manner; but the pygidium has no freely projecting points to the pleuræ.

L. Pahleni has straighter axial furrows bounding the glabella, and the pygidium is more elongated. The latter species is found in D_1 in the Baltic provinces, and the former in E.

L. angusta occurs in F_1 and F_2, and *L. deflexa* in D_2.

From the above comparison it will be seen that our Melmerby form does not completely agree with any of these species, though it shows so many points of affinity with all, and it appears necessary to regard it as a new species which may be suitably named *melmerbiensis*. The section to which it belongs is that termed *Homolichas* by Schmidt[3] and the author,[4] and in the latter's scheme of classification it lies in the second main division of the whole genus *Lichas*.

EXPLANATION OF PLATE XVII.

FIG. 1. *Lichas* (*Homolichas*) *melmerbiensis*, sp. nov. Complete individual. × 2. Dufton Shales, near Melmerby.
,, 2. Ditto. Ditto. × 2.
,, 3. Ditto. Thorax and imperfect pygidium. × 2.
,, 3*a*. Ditto. Thoracic segment enlarged to show ornamentation. × 5.
,, 4. Ditto. Posterior portion of middle part of head-shield. × 2.
,, 5. Ditto. Anterior portion of glabella. × 1½.
,, 6. Ditto. Pygidium. × 2.
,, 7. Ditto. Hypostome. × 2½.

IV.—ON THE GENUS *PYGOCEPHALUS* (HUXLEY), A PRIMITIVE SCHIZOPOD CRUSTACEAN, FROM THE COAL-MEASURES.

By HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S., F.G.S.

(PLATE XVIII.)

PYGOCEPHALUS COOPERI was first described by Professor Huxley from the Coal-measures of Paisley in 1857 (Quart. Journ. Geol. Soc., vol. xiii, pp. 363–369, pl. xiii), and a second specimen by the same author in 1862 (op. cit., vol. xviii, pp. 420–422, text-figure). Some additional specimens came into my hands for examination, and were communicated to the Glasgow Geological Society, in 1866 (Trans. Geol. Soc. Glasgow, vol. ii, pp. 234–247, pl. iii, figs. 1–3). In that paper I described a second species, which I named *Pygocephalus Huxleyi* (text-figure, p. 244, op. cit.). The specimens referred to above were obtained from the Coal-measures of Paisley, from Kilmaurs, and from near Manchester. Since then the late Mr. Henry Johnson, F.G.S., formerly of Dudley, obtained

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[1] Schmidt: op. cit., p. 104, t. iv, figs. 10–17.
[2] Schmidt: op. cit., p. 97, t. iv, figs. 6–8.
[3] Schmidt: op. cit., pp. 31, 40, 42.
[4] Reed: Q.J.G.S., vol. lviii (1902), p. 78.

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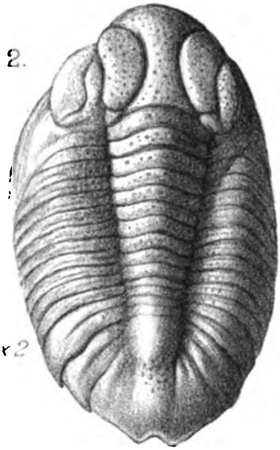

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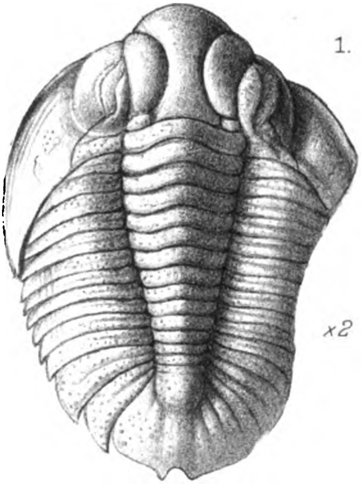

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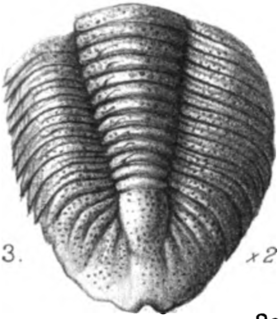

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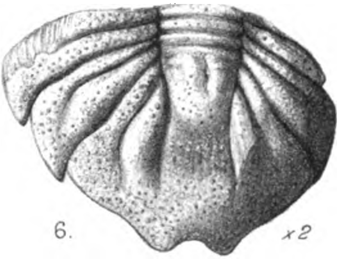

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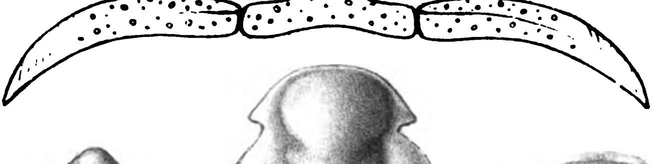

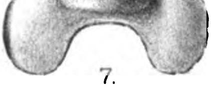

7. ×2½

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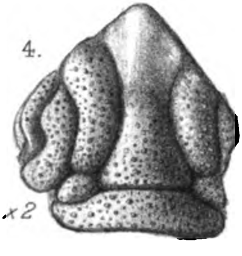

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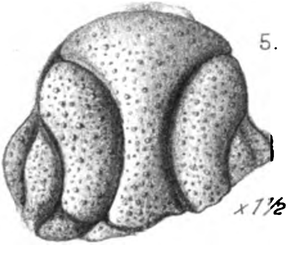

×1½

G. M. Woodward del. et lith. West, Newman imp

Lichas (Homolichas) melmerbiensis sp. nov.
Dufton Shales, near Melmerby.

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many examples of *Pygocephalus* from the Clay-ironstone nodules of Coal-measure age at Coseley, near Dudley, now in the Geological Department of the British Museum (Natural History Branch), Cromwell Road, S.W. These specimens are preserved in great perfection, and I had fully intended to figure them some years ago, but the pressure of other work caused them to be set aside for a time. Last year I received an example of *Pygocephalus* from Mr. Walter Baldwin, F.G.S., obtained from the Clay-ironstone of the Middle Coal-measures at Sparth, Rochdale (for description see Fig. 1, p. 405). I have also received through Mr. H. A. Allen, F.G.S., of the Geological Survey Museum, Jermyn Street, by the kindness of their owner, Mr. Herbert Hughes, Assoc. R.S.M., F.G.S., of Horseley House, Wolverhampton Street, Dudley, four most interesting specimens of *Pygocephalus* collected by him, two of which prove to be females,[1] a point of extreme interest not heretofore observed.

In his original paper (Quart. Journ. Geol. Soc., 1857, pp. 363–369, pl. xiii) Professor Huxley gave a very complete description of the underside in the male of *Pygocephalus Cooperi*, and, in the figures accompanying his paper, he shows the hexagonal plates forming the sternites of the thoracic segments; to the lateral marginal plates are attached the coxopodites of the thoracic limbs (pereiopods). He had also determined the presence of a distinct endopodite and exopodite to each thoracic limb. He writes as follows (p. 365):—"Attached to the outer boundaries of the lateral (ventral) plates, seven appendages are observable on one side and six on the other. In the more perfectly preserved appendages (fig. 1*c*) there may be distinguished a short, proximal, convex, subcylindrical joint, followed by at least three other slender and delicate articulations; of these the proximal one is the longest, the terminal next in length, and the middle one shortest. The terminal joint exhibits indications of further subdivision.

"The fifth limb on the right side presents a very important character, inasmuch as there lies parallel with and behind it a delicate, curved, many-jointed filament (fig. 1*e*), which externally abuts against the terminal joint of the appendage, and internally lies parallel with the longer cylindrical joint, and in close contiguity with the basal division of the appendage. I believe, in fact, that this filament is nothing less than the outer division of the appendage, or its exopodite; and I am inclined to think that traces of a corresponding filament are visible in some of the other appendages." On p. 367 he concludes further that "the small internal pair of appendages are the antennules, the large external ones antennæ; the seven segments are the sterna of seven thoracic somites, increasing in width from before backwards; the narrow longitudinal plates (lying outside the margin of the thoracic sternites) are the edges of a short carapace; and the semicircular disk is the termination of a large abdomen bent upon itself with the telson and uropods more or less flattened and crushed."

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[1] Since penning the above I have discovered two imperfectly preserved females of *Pygocephali* amongst Mr. Henry Johnson's specimens (registered number I. 1536) from Coseley, near Dudley, to be presently referred to again.

Professor Huxley then compares *Pygocephalus* with *Mysis*, the 'opossum-shrimp' of our own seas:—"In *Mysis*, as in *Pygocephalus*, the abdomen is very large, as compared with the thorax, and the carapace is short and delicate. The antennules present two subcylindrical basal joints; the antennæ have two large basal joints giving attachment to a large scale externally and superiorly, while internally the fusiform base of the internal division of the antennæ is formed by three joints, with the last of which a very long multiarticulate filament is continuous" (see Plate XVIII).

"There are seven pairs of conspicuous thoracic members in *Mysis*, the first pair of thoracic appendages being smaller than the others, and applied against the mouth; so, also, there are seven pairs of appendages in *Pygocephalus*," but the oral appendages in the fossil cannot be accurately determined.

"In *Mysis*, again, the thoracic limbs are short and feeble, and consist of two parts, an endopodite and exopodite, the latter being terminated by a many-jointed filament. They present the same peculiarities in *Pygocephalus*" (Pl. XVIII, Figs. 2, 9).

"In *Mysis* the sterna of the thoracic somites are well developed, and gradually increase in width from before backwards; so do those of *Pygocephalus*."

"The abdomen in *Pygocephalus* is much thicker and stronger in proportion than is that of *Mysis*"; and as seen from the drawings by Mr. Searle of the later specimens obtained, the telson, together with the three-jointed and paired uropods, on either side, differ greatly in form from those of *Mysis*, being far wider, more nearly resembling some of the Coal-measure Palæmonidæ figured by Dr. B. N. Peach, F.R.S.[1] This agrees with our experience concerning all these earlier forms of Crustacea, that they are *less specialized* in structure than are those of our modern times.

Huxley concludes that *Pygocephalus* is either a lowly form of Decapod or one of the Stomapoda, and he adds in a note, "the Schizopoda, including *Mysis*, are not essentially different from the Decapoda."

The result of our examination of the fine series of specimens of the male of *Pygocephalus*, obtained since 1857 for the British Museum (Natural History), tends not only to expand and perfect Professor Huxley's original description, but to prove the great accuracy of his observations of fifty years ago.

The additional specimens lately received from Mr. Herbert Hughes, obtained from the same bed of clay-ironstone nodules at Coseley, near Dudley, which formerly proved so prolific under the labours of the late Mr. Henry Johnson, have yielded clear evidence of the female of *Pygocephalus*. Those which are illustrated upon our Pl. XVIII, Figs. 5 and 6 show most distinctly the presence of a brood-pouch or marsupium on the ventral aspect of the thorax. Such structures are well known in many recent Crustacea, but have not hitherto been preserved in any fossil form.

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[1] See Trans. Roy. Soc. Edinb., vol. xxx (1888), pls. 8–10.

Dr. W. T. Calman, of the British Museum (Natural History), who has devoted himself for many years to the study of the Crustacea, has given special attention to these structures, and finds in them a valuable aid to the classification of the Crustacea. In a paper published in 1904[1] he wrote as follows (p. 150 op. cit.):—"Among the characters in which the Mysidacea differ from the Euphausiacea and agree with the Edriophthalmate orders, the most conspicuous is the possession by the female sex of a *brood-pouch*, or *marsupium*, in which the eggs and young are carried. It cannot be doubted that this structure is homologous throughout the whole series which I have named from this feature, the Peracarida,[2] in spite of real or alleged differences in the mode of its development. It is formed by a series of overlapping plates (which Claus considers with great probability to be of the nature of epipodites) attached to the inner side of the coxopodites of some or all of the thoracic limbs.

"When, as in many Isopoda, the coxopodites are fused with the body, the plates are attached to the sternal surface of the somites. In some cases these plates (or '*oostegites*') develop as bud-like outgrowths from the bases of the limbs, increasing in size at successive ecdyses as sexual maturity is approached; but in certain Isopoda it has been shown that the course of development is abbreviated, the 'oostegites' growing in the space between the sternal cuticle and the hypodermis, and being set free completely formed at a single moult."[3]

"Probably some similar process has given rise to the statement that the oostegites arise by splitting of the ventral cuticle in the Cumacea[4] and in the Isopod *Gnathia*.[5] At the same time it is certain that the formation of the brood-pouch is profoundly modified in certain parasitic Isopods of the tribe Epicaridea. In many of these the 'oostegites' develop in the typical fashion just described, but in the more specialized forms the structure is very different and hard to understand.

"In *Hemioniscus*, where the development has been worked out in detail by Caullery & Mesnil,[6] the marsupial cavity is hollowed out in a thickening of the ectoderm on the sternal surface, and is from the first completely closed. Further research will be required to show what relation this cavity bears to the normal marsupium."

"Apart from such exceptional cases, however, the possession of oostegites is a character quite peculiar to the group of orders included in the Peracarida and not found in any other Crustacea. It is true that the Euphausiidæ are described as carrying their eggs in sacs attached to the sternal surface of the thorax, and it has been assumed that these represent the marsupium of the Mysidacea. But Sars has pointed out that the 'ovisacs' are apparently formed by the consolidation of some cementing substance which is extruded along with the eggs from the oviducts."

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[1] "On the Classification of the Crustacea Malacostraca," by W. T. Calman, D.Sc.: Ann. & Mag. Nat. Hist., ser. VII, vol. xiii (1904), pp. 144–158.

[2] From πηρα, *pera*, a pouch, and *carida*, a shrimp.

[3] Cf. Leichmann, "Beitr. z. Naturgesch. d. Isopoden": Bibl. Zool., x (1891).

[4] G. O. Sars, "Beskr. af de paa Freg. Josephines Exp. fundne Cumaceer": Kongl. Svenska Vet.-Akad. Handl., ix, 13 (1871), p. 19.

[5] Dohrn, "Entw. und Organ. v. *Praniza* (*Anceus*) *maxillaris*": Zeitsch. f. wiss. Zool., xx (1870), p. 70.

[6] "Recherches sur l'*Hemioniscus balani*, Buchholz . . . . ": Bull. Sci. France et Belgique, xxxiv (1901), pp. 316–362, pls. xvii, xviii, 5 figs. in text.

Beneath I have given the classification proposed by Dr. W. T. Calman for Crustacea of the sub-class Malacostraca:—

Series **Leptostraca,** Claus, 1880.
- Division PHYLLOCARIDA, Packard, 1879.
  - Order NEBALIACEA, nov. nom.

Series **Eumalacostraca,** Grobben, 1892.
- Division SYNCARIDA, Packard, 1886.
  - Order ANASPIDACEA, nov. nom.
- Division PERACARIDA, nov. nom.
  - Orders MYSIDACEA.
  - CUMACEA.
  - TANAIDACEA.
  - ISOPODA.
  - AMPHIPODA.
- Division EUCARIDA, nov. nom.
  - Orders EUPHAUSIACEA.
  - DECAPODA.
- Division HOPLOCARIDA, nov. nom.
  - Order STOMATOPODA.

Dr. Calman gives the following diagnosis of his proposed division Peracarida:—Carapace, when present, leaving at least four of the thoracic somites distinct. First thoracic somite always fused with the head. Antennal protopodite typically of three segments. Mandible with lacinia mobilis (except in parasitic and other modified forms). Thoracic limbs flexed between fifth and sixth segments. 'Oostegites' attached to some or all of the thoracic limbs in female, forming a brood-pouch. No appendix interna on pleopods. Hepatic cæca few and simple. Heart elongated, extending through the greater part of the thoracic region, or displaced into abdomen. Spermatozoa filiform. Development taking place within the brood-pouch; young set free at a late stage." (Ann. & Mag. Nat. Hist., ser. VII, vol. xiii (1904), pp. 156, 157.)

The following may serve as illustrations of the frequent occurrence and variation in form of the brood-pouch in living Crustacea of different orders included in Dr. Calman's division Peracarida.

In the family Lophogastridæ (see the Rev. T. R. R. Stebbing's History of Recent Crustacea, 1893, p. 256) the marsupium consists of seven pairs of plates, the young undergoing their metamorphosis within the egg. The same arrangement occurs in the Eucopiidæ (op. cit., p. 260).

In the Mysidæ the marsupium is composed of seven, or more often of only two or three, pairs of plates (op. cit., p. 267).

In the Cymothoidæ the female has five pairs of marsupial plates on the first five pairs of thoracic limbs, and small supplementary plates on the last two pairs (op. cit., p. 339). In this family the plates of the marsupium are so imbricated that the last of the five pairs is outermost (op. cit., p. 394). In the Seroliidæ the marsupium consists of four pairs of plates (op. cit., p. 357) [formed probably between and set free by the separation of the ventral cuticle from the hypodermis]. In the Asellidæ the marsupial pouch is formed of plates pertaining to the first four, or to the second, third, and fourth segments of the thorax (op. cit., p. 376).

In the Dajidæ the first four pairs of imbricated plates form a movable lid to the front opening of the marsupium, the large fifth pair close it behind (op. cit., p. 398).

In the Entoniscidæ the marsupium is formed of five pairs of plates (op. cit., p. 405).

In one of the forms of parasitic Isopoda, of the family Bopyridæ (*Ione thoracica*), the imbricated plates of the brood-pouch in the female consist of seven pairs, and they closely resemble in form those of *Pygocephalus*, but they overlap one another in exactly the reverse order from back to front.[1]

There are other characters in the recent Peracarida which distinguish them from the Eucarida, in the structure of the mandibles and in certain characters presented by the thoracic limbs, but these we need not discuss here, as the fossil forms are not sufficiently delicately preserved, and cannot, of course, be dissected like recent specimens.

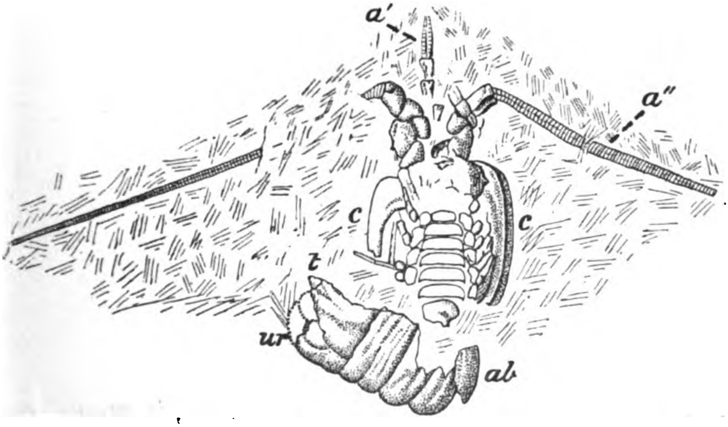

Fig. 1.—*Pygocephalus Cooperi*? (Huxley), from Coal-measures, Sparth, near Rochdale. Presented by Mr. Walter Baldwin to the British Museum (Natural History). Length of antennæ, 50 mm.; length of thorax, 25 mm.; length of abdomen, 25 mm. *a′*. antennules; *a″*. antennæ; *c*, *c*. lateral border of carapace; *ab*. abdomen; *ur*. uropods; *t*. telson.

In addition to the two well-preserved examples of the female in Mr. Herbert W. Hughes' collection figured on our Plate (Figs. 5 and 6), I have detected two imperfectly preserved females in the Museum collection (I. 1536), part of the late Mr. Henry Johnson's collection which I had previously overlooked. They serve to confirm the evidence afforded by Mr. Hughes' more perfect specimens.

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[1] Spence Bate & I. O. Westwood, "Sessile-eyed Crustacea," 1868, vol. ii, p. 255.

Measurements of the female of *Pygocephalus* (Fig. 6):—Extreme length of the more perfect female of *Pygocephalus*, 40 millimetres; breadth at base of antennæ, 10 mm.; breadth of caudal plates, where infolded towards base of thorax, 13 mm.; greatest breadth of *marsupium* near the centre of thorax, 12 mm.; breadth in front, 8 mm., posteriorly 10 mm.; number of imbricated plates, 7 pairs; length, 15 mm.; average length of plates, about 2 mm. The outer margins of the scales of brood-pouch are straight, the inner borders roundly curved. Measured along its convexity, length of abdomen in Mr. Johnson's specimen (I. 1536), 20 mm.; length of telson, 10 mm.; the margins of the 5 segments are recurved and their borders pointed.

In the male *Pygocephalus*, in which the oostegites are absent, the central thoracic plates are usually somewhat hexagonal in form; with these the small marginal plates (bearing the coxopodites of the thoracic limbs) are intercalated. In some examples of *Pygocephalus* the central plates are more quadrate-oblong. These differences may also be noticed in Huxley's figures of the thoracic plates of his two examples (Quart. Journ. Geol. Soc., 1857, pl. xiii, figs. 1*a*, *b*, 2, 3; also in our Plate XVIII, Fig. 3, and in Woodcut Fig. 1 in text). The telson and uropods in Huxley's example are represented as truncated (op. cit., pl. xiii, figs. 1*a*, *b*). The telson of those we figure now are pointed (see Pl. XVIII, Fig. 4). But possibly the caudal plates of Figs. 1 and 6 from Mr. Hughes' collection may have had a blunt and square telson with correspondingly

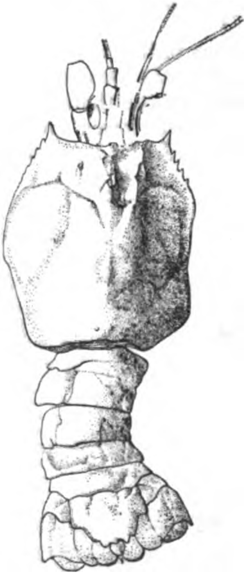

FIG. 2.—*Pygocephalus* (*Anthrapalæmon ?*) *Parkeri*, sp. nov., H. Woodw. Coal-measures: Sparth, near Rochdale. Obtained by Mr. W. A. Parker, F.G.S., and presented to the British Museum (Natural History). × 2 nat. size.

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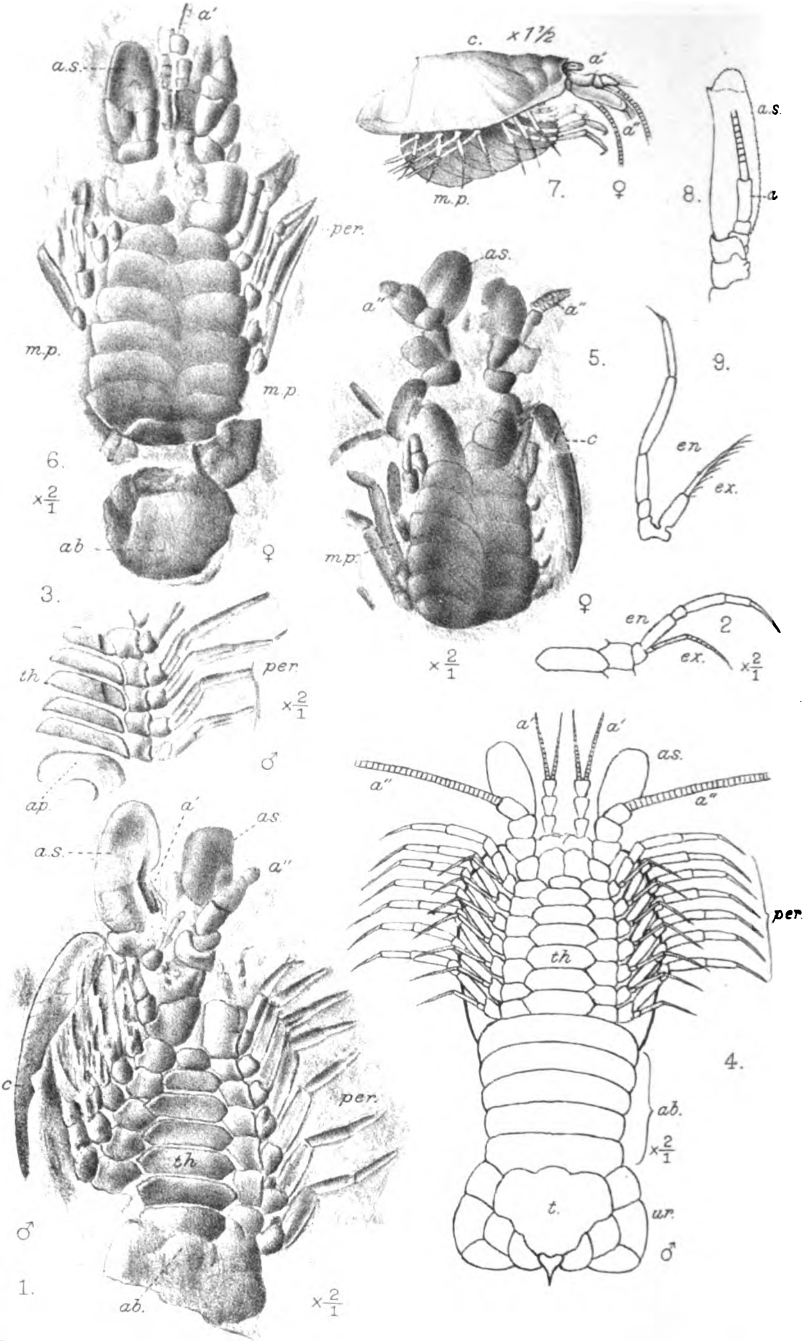

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Pygocephalus Cooperi, Huxley, Coal-Measures.
Coseley near Dudley.

broad uropods. Further research may show that the adult female differs from the male not only in the possession of marsupial plates, but in the form of its caudal plates also.

Another specimen from Sparth, Rochdale, was referred to by me a year ago (Brit. Assoc. Reports York Meeting) under the manuscript name of *Anthrapalæmon Parkeri*, H. W., but examining this specimen more critically I think this Crustacean should be referred to *Pygocephalus*, not to *Anthrapalæmon*. If this view is correct it is the only example hitherto met with in which the entire dorsal aspect of the Crustacean lies exposed.

It differs from *Pygocephalus Cooperi* in having four small and one large serration on the latero-anterior angles of the carapace, but the telson and its uropodites agree exactly with *Pygocephalus*. The antennæ also bear a large oval scale as in *Pygocephalus*. Although my evidence is incomplete I venture to place this form in the genus *Pygocephalus*, with the trivial name of *Parkeri*, after its discoverer, Mr. Wm. Albert Parker, F.G.S., of Rochdale.

In conclusion, I wish to thank my friend Dr. Calman for the very kind advice and assistance which he has given me in this investigation, and for the trouble he took in examining the specimens showing marsupial plates in order to verify my interpretation of their true nature.

EXPLANATION OF PLATE XVIII.

PYGOCEPHALUS COOPERI, Huxley.

Coal-measures—Clay Ironstone: Coseley, near Dudley.

FIG. 1.—View of ventral aspect of male specimen, ♂.
a.s. antennal scale; *a″.* antenna; *a′.* antennule.
c. margin of carapace.
th. hexagonal thoracic plates (sternites).
per. series of thoracic limbs (pereiopods).
ab. abdomen flexed ventrally upon the thorax.

,, 2.—A single thoracic appendage (after Huxley) showing (*en.*) the endopodite and (*ex.*) the exopodite.

,, 3.—Part of another specimen of male *Pygocephalus*, ♂.
th. thoracic sternites somewhat displaced.
per. five of the thoracic limbs showing endopodite and exopodite.
a.p. doubtful (anal ?) plate displaced.

,, 4.—An attempted restoration of the male ♂ underside, showing the antennules (*a′*, *a′*.); the antennæ (*a″*, *a″*.) with their long flagella and broad antennal scale (*a.s.*); the 7 thoracic sternites (*th.*) with corresponding paired pereiopods, each with exopodite and endopodite, the 5 abdominal plates (*a.b.*), followed by the telson (*t.*) with its two paired uropodites (*ur.*).

FIGS. 5 and 6.—Females of *Pygocephalus Cooperi*, showing 6 or 7 broad, scale-like, imbricated plates (*m.p.*), 'oostegites,' forming the marsupium in which the eggs and the immature young are carried. The other parts lettered are the same as in the male examples (Figs. 1, 3, 4).

FIG. 7.—Carapace with cephalo-thoracic appendages and marsupium (*m.p.*) of recent female Schizopod (*Eucopia australis*, Dana), copied from Challenger Report (Zoology), vol. xiii (Schizopoda), pl. ix, fig. 2. Enlarged about 1½ times nat. size.

,, 8.—Antennal scale (*a.s.*) with part of flagellum and basal joints of antenna of *Eucopea* (from same plate as Fig. 7).

,, 9.—One of the legs of *Ceratolepis* showing endopodite and exopodite, copied from same volume of Challenger Report as Figs. 7 and 8 (op. cit., pl. i, fig. 14).

V.—PRELIMINARY NOTE ON OVERTHRUST STRUCTURE AT LANGKOFL IN THE DOLOMITES.

By Dr. MARIA M. OGILVIE GORDON.

GEOLOGISTS who are familiar with the Dolomites of South Tyrol will know the transverse sections of Langkofl and Plattkofl Dolomite given by Geh. von Mojsisovics ("Dolomit-Riffe," 1879, pp. 191–204). Mojsisovics describes the Schlern Dolomite of Langkofl as resting conformably upon south-dipping Lower Muschelkalk and Werfen strata, and concludes that the Schlern Dolomite here represents a dolomitic facies of all the Mid-Triassic geological horizons—viz., the Mendola, Buchenstein, Wengen and Cassian horizons. The Lower Muschelkalk and Werfen strata then bend northward with a steep flexure and, according to Mojsisovics, conformably underlie the same Mid-Triassic series of Mendola, Buchenstein, Wengen, and Cassian horizons, but the Buchenstein horizon is here present in the nodular limestone facies, and the Wengen and Cassian horizons in their tufaceous facies.

In a paper which, I hope, may shortly be published, I have described the presence of two important thrust-planes, inclined southward, in the north wall of Langkofl and the adjacent hill-slopes on the north. One of these thrust-planes passes between the Schlern Dolomite of Langkofl and the group of Lower Muschelkalk and Werfen strata at its base. The Schlern Dolomite above the thrust-plane dips northward, the underthrust strata dip southward—rather more steeply than the thrust-plane which at the north wall has an average inclination of 15°–25° south-south-east.

The other thrust-plane is also inclined south-south-east and passes between the Werfen and Muschelkalk strata of the underthrust group and the Wengen lavas on the hill slopes adjacent to Langkofl on the north. For convenience, I have termed the segment of older Trias at the base of Langkofl the 'Montesora' segment.

Another thrust-plane inclined southward is present in the Plattkofl or south aspect of the Langkofl and Plattkofl group. The tufaceous and Cipit Limestone facies of Cassian strata in Fassa Joch dovetails towards the north with the dolomitic facies of the Cassian horizons in Plattkofl mountain. And a thrust-plane has carried the southern facies northward to some extent above the dolomitic facies.

I have farther shown that leading east-west eruptive fissures present on the north and south of the Langkofl and Plattkofl group in Mid-Triassic time were at that time undergoing depression relative to the intervening plateau upon which the calcareo-dolomitic deposits accumulated, and that simultaneously with the Mid-Triassic differential movements and eruptive invasions at east-west fractures a series of N.E.–S.W. flexures was in course of formation, the eruptive facies gaining ingress more especially in the troughs of that series.

My investigation of the Bufaure group of igneous mountains between Fassa and Contrin Valleys leads me to conclude that this was a depressed series of flexures in the course of both the east-west and N.E.–S.W. systems of plication, and was already broken in Mid-Triassic time by an intersecting network of fractures. The igneous rocks of the area are essentially fissure accumulations of lava, continuous with a rim of marginal sills which had found entry amidst the indipping strata of the surrounding Mid-Triassic flexures.

The leading east-west eruptive fissure of Bufaure, and a parallel fissure at Rodella Hill on the north, may be traced continuously eastward to the Fedaja and Buchenstein district, and westward through the slopes of Duron Valley to Seiser Alpe. Both on the north and south margins—for example, at Plattkofl and Sasso Pitschi on the north margin, and at Mairin Wand, Udai, Molignon, Rosszähne, and Schlern on the south margin—there is a rapid passage of all or part of the lavas and tuffs of the fissure facies into calcareo-dolomitic rocks of the same age. The still higher horizons of Schlern Dolomite can in some places, such as Pordoi in Sella Massive, be seen to give place to the "Schlern Plateau facies" of Raibl strata, which locally includes thin lavas, or to pass insensibly upward into well-stratified Raibl horizons of dolomite.

Round the west of the Seiser Alpe area, the Bufaure and Rodella east-west eruptive fissures become continuous with the leading east-west eruptive fissure which in Mid-Triassic time was active along the north of Seiser Alpe, the Langkofl and Sella Mountains, and the St. Cassian-in-Enneberg meadowland. This fissure is the "Pitzculatsch fault" in my Gröden Pass section (Q.J.G.S. 1899, vol. lv, pp. 567–569), and is that against which, subsequently to Mid-Triassic eras, the "Montesora segment" was pinched up between the fissure facies and the dolomitic.

The general conclusions which I draw from these observations will be fully set forth in the published paper, which will be accompanied by an illustrative series of parallel sections.

NOTICES OF MEMOIRS.

British Association for the Advancement of Science: Seventy-seventh Annual General Meeting held at Leicester, August 1st, 1907.

I.—Address to the Geological Section. By Professor J. W. Gregory, D.Sc., F.R.S., President of the Section.

I. *The Geological Society of London.*—1907! This is the centenary year of the Geological Society of London; next month the British geologists will celebrate the event, and their pleasure will be enhanced by the sympathetic presence of a distinguished company of foreign geologists.

With a just feeling of satisfaction may we celebrate this event; for to the Geological Society of London is due the conversion of geology from a fanciful speculation to an ordered science. Yet so quietly has this society done its work that the debt due to it is inadequately realised. When we consider what the world owes to geology in respect of its economic guidance, the intellectual stimulus of its conceptions, the reverence it inspires for the venerable and majestic universe, its liberating influence from dogma, we may rightly regard the work of the Geological Society as one of the most valuable British contributions to intellectual progress during the nineteenth century.

A hundred years ago the spirit of the eighteenth century still controlled much of the then orthodox geology. Jameson's "Elements of Geognosy," of which the preface is dated January 15th, 1808, taught, as the certain conclusions of geology, doctrines that had been reached by applying prejudiced speculation to imaginary facts. It was a manual of pure, *à priori*, Wernerian geology. The author claimed that to Werner "we owe almost everything that is truly valuable in this important branch of knowledge"; and that it was Werner "who had discovered the general structure of the crust of the globe and pointed out the true mode of examining and ascertaining those great relations which it is one of the principal objects of geognosy to investigate."

But Jameson's book was the death-song of Wernerian geology in British science. A new geology was developing, and the Geological Society of London ushered in its birth. No more should observations be made through the distorting medium of preconceived fancies! No more should geology be inspired by that heedless spirit which cares not to distinguish between fancy and fact! With youthful vigour the new geology would have nothing to do with the search for cosmogonies and such like fancy foods; and the Geological Society of London should be nourished on unadulterated facts.

The time was ripe for the change. No less a person than Goethe, once an enthusiastic votary of geology, was now, in his play of "Faust," holding up its teachers to ridicule. The theories "evolved from the inner consciousness" of Continental Neptunists and Plutonists were to Goethe excellent subjects for caricature. It was then the Englishman, Greenough, founded a society to turn geology from the pursuit of fleeting fancies and lead her to the study of sober but enduring facts. The members of this society were to abandon the quest of scientific chimæras; they were to leave to later generations the attempt to solve the universe as a whole.

The Geological Society has owed its influence to its bold, original purpose. It was not founded as a drifting social union of men with a common interest in a single science. Its object was to apply to geology one particular mode of research. It adopted as its motto this fine passage from Bacon:—

"If any man makes it his delight and care—not so much to cling to and use past discoveries, as to penetrate to what is beyond them—not to conquer Nature by talk, but by toil—in short, not to have elegant and plausible theories, but to gain sure and demonstrable knowledge; let such men (if it shall seem to them right), as true children of knowledge, unite themselves with us."

The methods of the society were as practical as its ideals. London, with characteristic unconventionality and originality, has used its scientific societies as its university for post-graduate teaching. Informally the Geological Society enrolled every British master of geology on its staff of unpaid professors, then set each of them to teach the branch of geology which he knew best. And these professors were no carpet knights; they were knights errant who derived their knowledge, not from books alone, but from their wanderings over hills and dales, in mines and quarries, by ice-polished rocks and water-worn valleys. At its meetings the leaders of the society announced what they had discovered, gave sure and demonstrable proofs of their discoveries, and showed in what direction the geological forces should be directed for the conquest of Nature. The goodly fellowship of the Geological Society has always encamped on the ever-advancing frontier of geological knowledge, where the well-surveyed tracks pass out into the bright, alluring realms of the unknown.

The actual founders of the Geological Society were apparently men of less showy intellect than the great Werner, whose teaching had intoxicated many of the most gifted of his enthusiastic pupils. They were men, like Horner and Greenough, who had a practical insight that enabled them to give a permanent help to the progress of science. They had that supreme gift, the power to see things as they are. It would not be fair to claim for them that they were the originators of accurate methods in geology; such methods had been used before their day—by William Smith in England, by Lehman in Germany, and by Desmarest in France. But these men, acting singly, had not been able to save geology from the eighteenth-century spirit of adventurous speculation, nor had they lifted from geology the burden of those quaint theories that made this science the butt of Voltaire's luminous ridicule.

The great achievement of the Geological Society has been this: as a corporate body it has been able to spread its influence very widely; its clear-sighted pursuit of a practical ideal has been adopted in other countries; its resolute rejection of the temptation to wander in dreamland has affected geological students all over the world. In this way has been laid a broad foundation of positive knowledge upon which modern geology has been built.

The fine self-restraint which induced the founders of the Geological Society to restrict its work for awhile to observing the surface of the earth has had its reward. The methods this society was founded to employ have been so widely used that we now have geological maps of a wider area than was known to geographers of a century ago. The general distribution of all the rocks on the earth's surface has been discovered; most settled countries have been surveyed in some detail; the main outlines of the history of life on the earth have been written and carried back almost as far as palæontologists are likely to go. There are doubtless fossiliferous areas still undiscovered in the 'back blocks' of the world; but, though negative predictions are proverbially reckless, it seems probable that palæontology will not carry geological history materially farther back. Fossils have been discovered in the præ-Cambrian rocks; the best known is the fauna described by Walcot from Montana; but his Beltina, the oldest well-characterised fossil, is still of Palæozoic type. It may be that the poverty of carbonate of lime, which is so characteristic a feature of most Cambrian and præ-Cambrian sediments, indicates that the bulk of the contemporary organisms had chitinous shells or were soft-bodied. Palæontology begins with the appearance of hard-bodied organisms; it can only reveal to us the dawn of skeletons, not the dawn of life. We are dependent for knowledge of the climate and geography of Eozoic time to the evidence of the sediments, of which there are great thicknesses beneath the fossiliferous rocks in most parts of the world.[1]

II. *The Geology of the Inner Earth.*—Now that this geological survey of the earth is in rapid progress; while the history of life has been written at least in outline; the chief fossils, minerals, and rocks have been described and generously endowed with names; and the manifold activity of water and air in moulding the surface is duly appreciated, it is not surprising to find that the centre of geological interest is shifting to the deeper regions of the earth's crust and to the problems of applied geology. The secrets of these deeper regions are both of scientific and economic interest. They are of scientific importance, for it is now generally recognised that the main plan of the earth's geography and the essential characters of the successive geological systems are the result of internal movements. The relative importance of those restless external agents that we can watch, denuding here and depositing there, has been exaggerated; probably they do little more than soften the outlines due to the silent heavings produced by the colossal energies of the inner earth.

The study of the deeper layers of the crust is of economic interest, for, with keener competition between increasing populations and with the exhaustion of the most easily used resources of field and mine, there is growing need for the better utilisation of soils and waters, and for the pursuit of deeper deposits of ore.

If a shaft be sunk at any point on the earth's surface a formation of Archæan schists and gneisses would probably always be reached; and, working backward, geological methods always fail at last—in primæval, Archæan darkness. The Archæan rocks still hide from us the earlier period of the earth's history, including that of all rocks which now lie beneath them. But already there are indications that the mystery of the 'beyond' is not so impenetrable as it seemed.

1. *The Nebular and Meteoritic Hypotheses.*—The eighteenth century explained the history of the earth by the nebular hypothesis of Laplace. Geologists respectfully adopted this idea from the astronomers; they accepted it as one of those essential facts of the universe with which geological philosophy must harmonise. The resulting theory represented the earth as originally a glowing cloud of incandescent gas, which slowly cooled, until an irregular crust of rock formed around a gaseous or molten core; as the surface grew cooler, the depressions in the crust were filled with water from the condensing vapour, forming oceans which became habitable as the temperature further fell. The whole earth was thought to have had

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[1] Such are the Algonkian sediments represented by the Huronian and Algonkians of America, the Algonkians of Scandinavia, the Karelian of Finland, the Briovarian of North-West France, the Heathcotian of Australia, the Transvaal and Swaziland systems of South Africa, the Dharwar and Bijawar systems of India, the Itacolumnite series of Brazil, etc.

a long period with a universal tropical climate, under which coral reefs grew where flow our polar seas, and palms flourished on what are now the Arctic shores. Still further cooling had established our climatic zones; and it was predicted that in time the polar cold would creep outward, driving all living beings toward the equator, until at length the whole earth, like the moon, would become lifeless through cold, as it had once been uninhabitable through heat. This theory has permanently impressed itself on geological terminology; and its corollaries, secular refrigeration and the contortion of the shrinking crust, once dominated discussions concerning climatic history and the formation of mountain chains. This nebular hypothesis, however, we are now told, is mathematically improbable, or even impossible; and it is only consistent with the facts of geology on the assumption that, in proportion to the age of the world, the whole of geological time is so insignificant that the secular refrigeration during it is quite inappreciable; hence geology can no more confirm or correct the theory than a stockbreeder could refute evolution by failing to breed kangaroos into cows in a single lifetime.

The theory of the gaseous nebula has been probably of more hindrance than help to geologists; its successors, the meteoritic hypothesis of Lockyer and the planetismal theory of Chamberlin, are of far more practical use to us, and they give a history of the world consistent with the actual records of geology. According to Sir Norman Lockyer's meteoritic hypothesis, nebulæ comets and many so-called stars consist of swarms of meteorites which, though normally cold and dark, are heated by repeated collisions, and so become luminous. They may even be volatilised into glowing meteoric vapour; but in time this heat is dissipated, and the force of gravity condenses a meteoritic swarm into a single globe. Some of the swarms are, says Lockyer, "truly members of the solar system," and some of them travel around the sun in nearly circular orbits, like planets. They may be regarded as infinitesimal planets, and so Chamberlin calls them planetismals.

The planetismal theory is a development of the meteoritic theory, and presents it in an especially attractive guise. It regards meteorites as very sparsely distributed through space, and gravity as powerless to collect them into dense groups. So it assigns the parentage of the solar system to a spiral nebula composed of planetismals, and the planets as formed from knots in the nebula, where many planetismals had been concentrated near the intersections of their orbits. These groups of meteorites, already as solid as a swarm of bees, were then packed closer by the influence of gravity, and the contracting mass was heated by the pressure, even above the normal melting-point of the material, which was kept rigid by the weight of the overlying layers.

This theory has the recommendation of being consistent with the history of the earth as interpreted by geology. For whereas the nebular hypothesis represents the earth as having been originally intensely hot, and having persistently cooled, yet geological records show that an extensive low-level glaciation occurred in Cambrian times in low latitudes in South Australia[1]; indeed, it seems probable that, in spite of many great local variations, the average climate of the whole world has remained fairly constant throughout geological time. Whereas it has often been represented, in accordance with the nebular theory, that volcanic action has steadily waned, owing to the lowering of the earth's internal fires and the constant thickening of its crust, yet epochs of intense volcanic action have recurred throughout the world's history, separated by periods of comparative quiescence. Whereas it has been assumed, as a corollary to the nebular theory, that the force which uplifted mountain chains was the crumpling of the crust owing to the contraction of the internal mass, yet observation reveals that the crust has been corrugated, and fold mountains formed by contraction to an extent far greater than secular cooling can explain.

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[1] As shown by the work of Professor Howchin, of Adelaide.

2. *The Materials of the Inner Earth.*—This planetismal hypothesis is not only consistent with geological records, but also with the known facts as to the internal composition of the earth and the structure of extra-terrestrial bodies as revealed by meteorites. Meteorites are of two main kinds—the meteoric irons, which consist of nickel iron, and stony meteorites, which are composed of basic minerals. Some of the stony meteorites have been shattered into fault breccias, showing that they are fragments of larger bodies which were subject to internal movements, like those that have formed crush conglomerates in the crust of the earth. Those stony meteorites, therefore, both in composition and structure resemble the rocks in the comparatively shallow fracture zone of the earth's crust. The nickel-iron meteorites, on the other hand, represent the barysphere beneath the crust.

The earth appears to consist of material similar to that of the two types of meteorites; but whether the proportions of the two materials in the earth represent their proportions in other bodies and in meteoric swarms is problematical. There appear to be no satisfactory data for an estimate of the relative abundance in space of the iron and stony meteoric material. Stony meteorites have been seen to fall far more frequently than iron meteorites; but the largest known meteorites are of the nickel-iron group, although this material, in moist climates, very soon decays. The most reliable indication as to the relative amounts of the stony and nickel-iron meteorites is given by a comparison of the weight of the two types of material in meteorites of which the fall was seen. According to Mr. Fletcher's list of the meteorites in the British Museum up to 1904, the collection included 319 specimens of which the fall is recorded: of them 305 specimens were stony meteorites of an average weight of 2·63 lbs., 9 were iron meteorites of an average weight of 2·31 lbs., and 5 were siderolites (or meteorites containing a large proportion of both silicates and nickel-iron) of an average weight of 54 lbs.[1] Therefore, according to this test, the stony materials would appear to be the more abundant. But if all known meteorites are considered, the iron group far outweighs the other; for the iron meteorites in the British Museum collection weighed 11,873 lbs., as against a total weight of only 865 lbs. of stony meteorites. The available evidence suggests that the stony meteorites fall the more frequently on the earth, but the meteoric irons come in such large masses that they outbalance the showers of the smaller stones.

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[1] The weights are given in pounds avoirdupois. For the calculation I am indebted to Mr. W. R. Wiseman, of the Geological Department of Glasgow University.

We might have expected help from another source in examining what lies below the Archæan rocks. Cannot the relative proportions of the stony and metallic constituents in the earth help us? Unfortunately, this proportion is as uncertain as that of stony and iron meteoritic material. The best-established fact about the interior of the earth is that its materials are much heavier than those of its crust. The specific gravity of the earth as a whole is about 5·67; the specific gravity of the materials of the crust may be taken as about 2·5, while that of the heavier basic rocks is only about 3·0. Hence the earth as a whole weighs about twice as much as it would do if it were built of materials having the same density as those which form the crust.

Two explanations of the greater internal weight of the earth have been given. According to one, the earth is composed throughout of the same material, and the internal mass is only heavier because it is compressed by the weight of the overlying crust. Laplace estimated that the material would gradually increase in density from the surface to the centre, where its specific gravity would be 10·74, and the calculations of Schlichter show that condensation due to compression may be adequate to account for the greater internal weight.

According to the alternative or segregation theory, the difference in density is explained as due to a difference in composition; the interior of the earth is thought to be heavier owing to the concentration of metals within it. The probability of this metallic interior has been advanced from several lines of evidence; and the assumed metallic mass has received from Posepny the name of the 'barysphere,' or heavy sphere. According to this view the earth is essentially a huge ball of iron, which, like modern projectiles, is hardened with nickel; and it is covered by a stony crust, the materials of which were primarily separated from the metallic mass, like the slag formed on a ball of solidifying iron in a puddling furnace.

It has been objected that the weight of the earth is not great enough for much of it to be composed of metallic iron or of meteoritic material. The specific gravity of iron under the pressure at the earth's surface is about 7·7, and it would be even greater when compressed in the interior. But the barysphere is doubtless impregnated with much stony material that would lessen its weight. An estimate by Farrington (1897) of the average specific gravity of the meteorites of which the fall had been recorded is only 3·69. According to the Rev. E. Hill (1885) the mean specific gravity of all the meteorites in the British Museum was 4·5; and, though Mr. Hill duly considered the effect of compression, he concluded that "the density of the earth is perfectly consistent with its being an aggregation of meteoric materials." Moreover, within the metallic barysphere there may be a core of lighter material; for earthquake waves travel more slowly in the central core of the earth than in the intermediate zone, or are even suppressed altogether there; hence the centre of the earth may be occupied by matter less compact than that of the shell around it; and, according to Oldham's calculations, the light central core occupies two-fifths of the diameter of the earth.

The evidence of density alone, therefore, gives no convincing evidence of the nature of the earth's interior; and geologists have been left with no conclusive reason for choosing between the condensation and segregation theories. Radio-activity has, however, unexpectedly come to our aid, and has disclosed a further striking resemblance between the internal mass of the earth and the iron meteorites. It has supplied direct evidence about the constituents of the earth at depths which have hitherto been far beyond the range of observation. Mr. Strutt has shown that radium is probably limited within the earth to the depth of 45 miles, that the deeper-lying material is free from radium, and that this substance is not found in iron meteorites.

The agreement in radio-active properties between the iron meteorites and the interior of the earth is an additional and weighty argument in favour of the view that the earth is largely composed of nickel iron.

3. *Physical Conditions and Temperatures.*—The physical condition in which the material exists is now of secondary interest. The old controversy as to whether the earth has a molten interior inclosed within a solid shell has lost its importance, because it has become a mere matter of definition of terms. The facts which led geologists to believe that the interior of the earth is fluid are consistent with those which prove that the earth is more rigid than a globe of steel. For under the immense pressure within the earth the materials can transmit vibrations and resist compression like a solid; but they can change their shape as easily as a fluid. They are fluid just as lead is when it is forced to flow from a hydraulic press. Not only are geologists now justified in their belief that the deeper layers of the earth's crust are in a state of fluxion, but, according to Arrhenius (1900), the earth is solid only to the depth of 25 miles, below which is a liquid zone extending to the depth of 190 miles; and below that level, he tells us, "the temperature must, without doubt, exceed the critical temperature of all known substances, and at this depth the liquid magma passes gradually to a gaseous magma." This distinguished physicist gives a description of the earth's interior which reminds us of the views of the early geologists. Arrhenius's theory rests, however, on the existence within the earth of exalted temperatures; and this assumption a geologist may now hesitate to accept with less risk of getting into disgrace than he would have run a few years ago. It is improbable that the rapid increase of heat with depth which is observed near the surface should continue below the lithosphere; for, if the earth consists in the main of iron, even although it be arranged as a mesh containing silicates in the interspaces, the heat conductivity might be sufficient to keep the whole metallic sphere at a nearly equal temperature. Here, again, Mr. Strutt's work on radio-activity is in full agreement with the requirements of geologists, for he estimates that below a crust 45 miles thick the earth has a uniform

temperature of only 1,500° C. Whether the further conclusion that this heat is due to the action of the radium in the crust be established or not, it is gratifying to hear a physicist arguing in favour of a moderate and uniform internal temperature.

All that the actual observations prove and that geological theories require is that the material within the earth be intensely hot, and that it lie under such overwhelming pressure that it would as readily change its form and as quickly fill up an accessible cavity as any liquid would do. Whether such a condition is to be described as solid, liquid, or gaseous is of little concern to geologists.

III. *The Deep-seated Control over the Earth's Surface.*—The modern view of the structure of the earth adds greatly to the interest of its study, for it recognises the world as an individual entity of which both the geological structure and the history have to be considered as a whole. Once the earth was regarded as a mere lifeless, inert mass which has been spun by the force of gravity, that hurls it on its course into the shape of a simple oblate spheroid. Corresponding with this astronomical teaching as to the shape of the world was the geological doctrine that all its topography is the work of local geographical agents, whose control over the surface of the earth is as absolute as that of the sculptor's chisel over a block of marble.

Both these conceptions are now only of historic interest. The irregular individual shape of the earth is expressed by its description as a geoid. The processes which have produced its varying shape have also controlled its geological history and evolution, for they cause disturbances of the crust, which affect the whole earth simultaneously; and so the geographical agents are given similar work and powers at the same time in different places.

Hence there is a remarkable worldwide uniformity in the general characters of the sedimentary deposits of each of the geological systems. The last præ-Cambrian system includes thick masses of felspathic sandstones alike in the Torridonian of Scotland, the sparagmite of Scandinavia, the Keweenawan Sandstones of the United States, and perhaps also the quartzites of the Rand. The Cambrian has its greywackes and coarse slates and its numerous phosphatic limestones; the Ordovician its prevalent shales and slates; the Silurian its episodal limestones and shales. The Devonian has its wide areas of Old Red Sandstones as a continental type, while its marine representatives show the prevalence of coarse grits and sandstones in the lower series, of limestones and slates in the middle series, and the recurrence of sandstones in the upper series; and this sequence occurs alike in North-Western Europe, in America, and Australia. The Carboniferous contains the first regional beds of thick limestone and the first important Coal-measures. The Trias is as characterised by rocks indicating arid continental conditions in America and Australia and South Africa, as Professor Watts has shown then prevailed in the neighbourhood of Leicester. In the Mesozoic era we owe to Suess the demonstration of the worldwide influence of those marine encroachments or 'transgressions' whereby the great continents of the Trias were gradually submerged by the rising sea.

Speaking generally, there is a remarkable lithological resemblance between contemporary formations in all parts of the world. This fact had been often remarked, but was usually dismissed as due to a number of local isolated coincidences of no special significance. But the coincidences are too numerous and too striking to be thus lightly dismissed. They are among the indications that the main earth-changes have been due to world-wide causes, which led to the predominance of the same types of sedimentary rocks during the same period in many regions of the world.

The conditions that govern the geological evolution and general geography of the earth are probably due to the interaction between the earth's crust and the contracting interior; they may take place as slow changes in the form of the earth, causing the slow rising or lowering of the sea surface, or the slow uplift or depression of regions of the earth's crust; or they may give rise to periods of violent volcanic action in many parts of the earth, between which may be long periods of quiescence. The geographical effects of changes in the earth's quivering mass affect distant regions at the same time. Therefore the landmarks of physical geology will probably be found to give more precise evidence as to geological synchronism than those of palæontology, on which we have hitherto had to rely.

(To be concluded in our next Number.)

II. — British Association for the Advancement of Science. List of Titles of Papers read in Section C, Geology, August 1st to 7th, 1907.

Presidential Address by Professor J. W. Gregory, F.R.S. (p. 409.)

C. Fox-Strangways.—Geology of Country round Leicester. (p. 420.)

Professor W. W. Watts, F.R.S.—The Geology of Charnwood Forest.

Dr. F. W. Bennett.—The Felsitic Agglomerate of Charnwood Forest.

Dr. B. Stracey.—The North-West District of Charnwood Forest. (p. 420.)

A. R. Horwood. — The Palæontology of the North Derbyshire Coalfield. (p. 421.)

H. T. Ferrar.—Some Desert Features.

Trias Report—Investigation of the Fauna and Flora of the Trias of the British Isles.

- (*a*) *Dr. Smith Woodward.*—On *Labyrinthodon leptognathus*, Owen.
- (*b*) *H. C. Beasley.*—Footprints from the Trias.
- (*c*) *J. Lomas.*—Footprint Slab in Museum of University of Liverpool.
- (*d*) *A. R. Horwood.*—The Flora and Fauna of the Trias.
- (*e*) *L. J. Wills.*—Fossils of the Lower Keuper of Bromsgrove.

Professor H. G. Seeley, F.R.S.—On the Structure of the Mandible of a South African Labyrinthodont.

T. O. Bosworth.—The Origin of the Upper Keuper.

W. Keay & M. Gimson.—The Relation of the Keuper Marl to the Pre-Cambrian Rocks at Bardon Hill.

H. Bolton & C. J. Waterfall.—On the Occurrence of Boulders of *Strontia* in the Upper Triassic Marls of Abbott Leigh, near Bristol.

Dr. Cullis.—On a peculiarity in the Mineralogical Constitution of the Keuper Marl.

Discussion on "Iron Ore Supplies," to be opened by Bennett Brough and Professor Sjögren.

Professor J. Joly.—The Distribution of Radium in the Rocks of the Simplon Tunnel.

W. G. Fearnsides.—On Pisolitic Iron-ores from North Wales. (p. 422.)

F. Raw.—The Trilobite Fauna of the Shineton Shales.

F. Raw.—Development of *Olenus Salteri.*

Dr. A. Vaughan.—Report on Carboniferous Faunas.

W. G. Fearnsides.—Report on Place-Names.

Professor S. H. Reynolds.—Report on Pre-Devonian Rocks of the Mendips.

Professor J. Milne, F.R.S.—Destructive Earthquakes.

Professor Frech.—Mountain Building and Seismology.

J. W. Stather.—Report on Kirmington Deposits.

J. W. Stather & T. Sheppard.—Gravels of Holderness.

J. Lomas.—On a Marine Peat at Liverpool.

A. R. Horwood.— A Section of Middle Lias at Bellesdon.

Rev. S. S. Dornan.—Ancient Volcanoes of Basutoland.

E. Greenly.—Report on Anglesey Rocks.

Dr. Wheelton Hind.—Report on Carboniferous Zones.

Report on Erratic Blocks.

Titles of Papers read in other Sections bearing upon Geology :—

SECTION A.—GENERAL PHYSICS.

A. O. Rankine.—On a theoretical Method of attempting to detect relative Motion between the Ether and the Earth.

Report of the Committee on Seismological Observations.

Professor E. Rutherford, F.R.S.—On the Production and Origin of Radium.

Professor E. Rutherford, F.R.S., & Dr. J. E. Petavel, F.R.S.—The Effect of High Temperature on the Activity of the Products of Radium.

T. J. J. See.—Results of Recent Researches on the Physics of the Earth.

SECTION B.—CHEMISTRY.

Professor Phillips Bedson.—Explosions in Coal-mines: Experiments illustrative of the Inflammability of Mixtures of Coal Dust and Air.

SECTION D.—ZOOLOGY.

Report of the Committee on the *Index Animalium.*

SECTION E.—GEOGRAPHY.

Professor J. W. Spencer.—The Recession of Niagara.

H. T. Ferrar.—Physical Geography of the Etbai Desert of Egypt.

Dr. Vaughan Cornish.—The Jamaica Earthquake.

SECTION H.—ANTHROPOLOGY.

Report of the Committee to conduct Explorations with the object of ascertaining the Age of Stone Circles.

Report of the Committee to Investigate the Lake Village of Glastonbury.

SECTION K.—BOTANY.

Professor F. W. Oliver, F.R.S.—On the Structure and Affinities of *Physostoma elegans* (Williamson), a Pteridospermous seed from the Coal-measures.

D. M. S. Watson.—The Cone of *Bothrodendron mundum.*

PAPERS READ IN SECTION C (GEOLOGY), BRITISH ASSOCIATION, LEICESTER, AUGUST, 1907.

III.—NOTES ON THE GEOLOGY OF LEICESTERSHIRE. By C. FOX-STRANGWAYS, F.G.S.

THE chief features of the district were briefly described, with a general account of the formations that are exposed throughout the county. These are comprised in the following main divisions in descending order: Recent and Pleistocene, Jurassic, Triassic, Permian, Carboniferous, and Pre-Cambrian. The first of these includes the river deposits and glacial beds. The Jurassic rocks comprise only the two lower subdivisions of the Lincolnshire Limestone and the Northampton Sand, together with the Lias. The Trias occurs in the usual two divisions of Keuper and Bunter. The Permian consists of breccia and marls, the age of which is to some extent doubtful. The Carboniferous is well exemplified in the three subdivisions of Coal-measures, Millstone Grit, and Limestone; but the lower beds are not of the importance they attain elsewhere. The Pre-Cambrian rocks are divisible into three main groups, as shown by Professor W. W. Watts—the Brand Series, the Maplewell Series, and the Blackbrook Series. Special attention was directed to the more important exposures of these rocks, and to the principal points in the local geology that are obscure and require further elucidation.

IV.—THE NORTH-WEST DISTRICT OF CHARNWOOD FOREST. By BERNARD STRACEY, M.B., F.G.S.

AS the north-west of Charnwood Forest is approached the rocks become more altered, the faulting is greater, and igneous rocks are met with. The vent which ejected the rocks of the forest seems to lie in this direction.

Bardon Hill.—The centre and part of the north flank are composed of rock resembling an igneous rock; evidence is given to show that this rock differs from the agglomerates found in the north-west area, with which it has hitherto been correlated. Certain rocks between the Bardon rock and the Peldar porphyroid seem to bear some relation to the felsitic agglomerate.

Birchill Plantation.—Recent research in this exposure has shown the identity of the rock with that found at Bardon Hill. On the north side rocks belonging to the Felsitic Agglomerate Series have also been found.

Peldar Tor.—The porphyroid exposed in the large quarries contains inclusions of other rocks, which have been generally considered as segregation masses. An undoubted dyke in the middle of Peldar Tor has been exposed.

Ratchet Hill.—An exposure in this hill shows the presence of rocks on the felsitic agglomerate horizon. At the north-west end a porphyroid occurs which seems to be identical with the porphyroid at Cadman Wood.

Swannymote and Trilobate.—Rock belonging to the Felsitic Agglomerate Series runs between these two places; it has been much altered, and has not hitherto been recognised as belonging to the felsitic agglomerate.

V.—A CONTRIBUTION TO THE PALÆONTOLOGY OF THE NORTH DERBYSHIRE AND NOTTS COALFIELD, OR THE SOUTHERN PART OF THE NORTH MIDLAND COALFIELD. By A. R. HORWOOD, Sub-Curator, Leicester Corporation Museum.

A SUMMARY was given of the extent and position of the North Midland Coalfield. Allusion was then made to the previous work connected with the palæontology of the district. This was very limited, and the correlation of the Top Hard Coal with the Main Coal of Leicestershire, and of the Black Shale with the Arley Mine of Lancashire, had not been founded on fossil evidence.

Recently the resurvey of the district by the Geological Survey and some important borings had added much to our knowledge of the fossil flora and fauna met with.

As a result of these investigations, and by the aid of a summary of all the previously recorded organic remains from this area, the author was able to arrive at the following conclusions:—

1. That the flora of the Top Hard Coal, as afforded by specimens from Pleasley, indicates that it is of the same age as that of the Main Coal of Leicestershire and South Derbyshire (in both the Western or Moira and Eastern or Cole Orton Districts), i.e. of Middle Coal-measure age, occupying a position rather more than midway in that division of the Coal-measures.

2. The fauna of the horizon at Mansfield, Notts, 630 feet above the Top Hard Coal, indicates, as pointed out by Mr. Walcot Gibson, a horizon equivalent to the Gin Mine or Twist Coal of the North Staffordshire Coalfield, i.e. near the top of the Middle Coal-measures and commencement of the Transition series, or Black Band group, which would occupy a position slightly higher. Eastward and above this horizon the whole of the Upper Coal-measures are represented, though feebly developed.

3. The Coal-measures of North Derbyshire are, as a whole, entirely confined to the limits of the Grey or chief coal-bearing series (Lower

and Middle Coal-measures), like the Leicestershire and South Derbyshire Coalfield, of which it is a continuation; and none of the Red series (or Transition series and Upper Coal-measures) of the North Staffordshire type are met with in this area west of a line somewhat east of the Nottinghamshire and Derbyshire County boundary between Bolsover and Stanton, though this line probably curves westward in the north, just south of Rotherham, and eastwards, south and south-east of Nottingham.

A summary of the fossil flora and fauna of North Derbyshire and Nottinghamshire, as at present known, was given, with the horizon and locality of the specimens cited. This, though preliminary, was in extension of the work already accomplished in the Leicestershire and South Derbyshire Coalfield, shortly to be published, and in other fields, and supplementary to the work of Ward, Hind, and Stobbs in the North Staffordshire Coalfield on the mollusca and fish fauna of that area, and of Kidston on the fossil floras of Yorkshire and North and South Staffordshire.

VI.—On the Pisolitic Iron-ores of Wales. By W. G. Fearnsides, M.A., F.G.S.

THE first part of the paper discusses the occurrence of the well-known iron-ores of Caernarvon and Merioneth, and shows that though they have been taken by various writers as marking a well-constituted subdivision of the Tremadoc slates they are really of the nature of fissure phenomena, and may occur at almost any horizon.

The various worked exposures seem always to agree in the following particulars:—

(1) They are associated with the occurrence of large hypabyssal or minor plutonic intrusions of sill-like habit, and occur among stratified rocks along the limit of the sill's metamorphic area.

(2) They occur in more or less lenticular masses, of no considerable lateral extent, often heaped together and separated by crushed shale partings in a way which may suggest bedding, but often thinning out yet maintaining a linear arrangement across considerable tracts of country.

(3) Considerable lenticles of ore are always associated with dark-blue or black shales or slates, which nearer to the igneous intrusion have become bleached and spotted through the influence of that intrusion. On the side of the ore body nearest the intrusion the country rock is usually little disturbed, and lies evenly, but on the side remote from the intrusion the country rock is crossed and recrossed by planes of slickenslide, and is often intensely nodular.

The more important stratigraphical horizons which have developed pisolitic ore bodies in the North Welsh district are:—

(1) Lower Lingula flags. Bettws Garmon. Black shales which underlie the grey flaggy sandstones with *Lingulella* beds.

(2) Upper Lingula flags. North flank of Aron Mawddy. Adjoining shales contain *Peltura scarabæoides*.

(3) Upper Arenig Shales. Moelwyn Bach; Milltirgerig, Arenig; below Llyn y gader, Cader Iris. Country rock contains abundant *Didymograptus bifidus*.

(4) Llandeilo Shales (Glenkiln facies). Tiddyn Diewm, Tremadoc. Country rock contains graptolites of the *Didymograptus Murchisoni* and *Cœnograptus gracilis* zones.

The workings of Pistyll near the Rivals seem to belong to a horizon higher than any of these, and may be among the Hartfell (Bala) shales.

The second portion of the paper deals with the probable petrological and chemical history of the iron-ores.

Evidence is brought forward to show that the ore bodies have been only profitable near the present surface, and when smelted with wood charcoal. They are always very rich in pyrites or marcassite, which in certain specimens from the deep termination of an adit makes up about 60 or 70 per cent. of the rock. The ores are always impure, and contain much crushed, streaky or fibrous shale between the pisoles. Where freshest the pisoles of sulphides show only radial arrangement of the constituent fibres, but there may also be concentric structures which are masked by the opacity of the mineral. The radial fibres of sulphidic minerals usually grow out from or around quartz grains or other clastic fragments of country rock or of earlier formed pisolite grains. During oxidation the sulphidic material is attacked in stages from the outside and passes by obscure processes, first to a colourless and soluble green pleochroic mineral, and afterwards to fibrous limonite and compact magnetite, and it is the differential development of the various stages which gives the resultant pisoles of the profitable ore their well-marked concentric structure.

That all the pisolitic grains contained in the iron-ores of North Wales have been formed as radial growths of iron sulphides is not yet clear, but the method of their geological occurrence will well accord with the hypothesis that they may be the concentration products of the non-carbonaceous colouring matters driven off by the heat of the intrusion from the black shales considered above.

An occurrence of perfectly fresh masses of radial pyrites at the limit of a 12–20 feet metamorphic aureole in the Llandeilo shale of Harper Quarry, Builth, shows that such concentration can occur on a small scale, while the finding of considerable lenticles of iron-ore which are wholly pyrites, and have been concentrated during the turning of coal into anthracite in the Emlyn Mine, Llandeby, near Llandeilo, would seem to show that recrystallized pyrites does tend to take on a pisolitic habit.

REVIEWS.

AUSTRALIAN GEOLOGY.

STANFORD'S COMPENDIUM OF GEOGRAPHY, ETC. New issue, 1907. AUSTRALASIA. Vol. I: AUSTRALIA AND NEW ZEALAND. By J. W. GREGORY, D.Sc., F.R.S., Professor of Geology in the University of Glasgow. (London: Edward Stanford.)

THE whole of this volume abounds with geographical and geological references, as might be expected from the author, and is also exceedingly well illustrated with maps, etc. Chapter iv, "The

Geographical Structure and Resources of Australia," pp. 84–115, contains the geological map facing p. 104, and there is also a physical map facing p. 84, with a small map on p. 93 showing the main geographical divisions. Gregory considers that, with the exception of the east coast of Australia, the coasts as a rule have no intimate connection with the geological structure of the adjacent lands. The course of these coasts has been determined by great subsidences, which have formed the ocean basins round Australia, instead of by movements parallel to the shore. The great arm of the sea on the south coast, known as Spencer Gulf, has been formed by subsidence along two lines of fault, being in fact a rift-valley. This depression seems to be continued in the great central plain system terminating in the Gulf of Carpentaria on the north.

There are, in fact, three very unequal and dissimilar areas constituting the Australian continent. Commencing from the eastward, the first and by far the most interesting division is that of the East Australian highlands and its dependencies; this mountain-system roughly conforms to the east coast from Torres Strait to Bass Strait, curving round to face the latter, where it constitutes the highlands of Victoria. It is in the angle thus formed, in the extreme south-east of the continent, where the mountain-system attains its maximum development. On the seaward side of the East Australian highlands are areas of coastal plain, which in New South Wales are of considerable width, and usually contain the most important centres of population. On the landward side of the mountain-system, both in Queensland and New South Wales, the country gradually slopes towards the central depressed area, shooting off its surplus water either by the Murray system into the sea, or by interior drainage towards the Lake Eyre basin. The geological structure of these eastern highlands is complex, and bears but little resemblance to a typical mountain chain. There is a considerable mass of crystalline rock, described as Archæan and plutonic, in the northern part of the Queensland section, which is unassociated with any development of the older Palæozoics, but has the sea on one side and rocks of Cretaceous age on the other. In the central portion of the highlands, between lat. 25° and 30° S., Archæan rocks are indicated which in some cases are flanked by the older Palæozoics, whilst in the south-east corner (New South Wales and Victoria) there are several masses of Archæan rock associated with a much larger development of the older Palæozoics. The most important display of Carboniferous rocks is to be found in the region lying between 20° and 35° S. lat. This subject had best be considered under the separate Colonies. Patches of Triassic and Jurassic rock occur here and there, and there is a large development of Tertiary volcanics throughout this division, which appears to attain their widest extension in the Great Valley of Victoria. The entire mountain-system consists in a geographical sense of a series of plateaux, and Professor Gregory assures us that the highest summit in Australia, Mount Kosciusko (7,336 feet), is only a blunt hummock on the surface of a high plateau. These plateaux have been greatly dissected, so that the gorges are numerous and deep, and he further points out that the best-known mountains visible from the coast are only the scarps of the inland plateau. This rule applies also to the third grand division, viz. Westralia.

The second grand division also runs south and north from the southern sea to the Gulf of Carpentaria, and is described as the region of the Great Plains, formed, Professor Gregory thinks, by subsidence. A large portion of this is less than 500 feet above sea-level; the shores of Lake Eyre are said to be 39 feet below that level. It is, in fact, an extensive basin whose further submergence would tend to convert the continent of Australia into two separate islands. The greater part of this depressed area is occupied by rocks of Cretaceous age as determined by their fossils.

The third grand division is larger than the other two combined, and consists of an endless series of upland plateaux of moderate elevation up to about 2,000 feet, much of which is practically a desert. This immense mass consists to a great extent of Archæan rocks associated in the north-east with a wide stretch of older Palæozoics, though parts of the interior may be still unexplored. It appears to have been unsubmerged, like peninsular India, for a long period, and has a fringe of newer rocks on its western margin, in which the early settlements of Western Australia are situated. The mineral resources of this and the two other grand divisions of the Australian continent may be gathered from Professor Gregory's separate notices of the individual Colonies.

New South Wales.—As previously noted in considering the character of the East Australian highlands, the south-eastern corner is composed of Archæan and Lower Palæozoic rocks, mostly striking north and south. These older rocks gradually decrease in height as they are followed northwards, until they disappear below the Upper Palæozoic rocks which contain the great coalfields. To the north of this area the older rocks reappear and are continued to the Queensland frontier. The mountains result in the main from the dissection of plateaux by river-action. These are in a very youthful stage of dissection, and their marvellous gorges and cliffs—expressions of youth—provoke the wonder of the beholder by reason of their diverse forms. The lavas of Tertiary age, which occur in some places, also lend themselves to this kind of scenery, and there are peaks west of the Blue Mountains which consist of trachyte and andesite. On the east side of the mountain-system the coastal plains have an average width of 40 miles, though in the valley of the Hunter River the width reaches 150 miles. The western plains, on the other side of the mountain-system, include some of the largest true plains in the world. They are mostly dry, but sometimes in places so flooded that steamers have been known to discharge their cargoes 25 miles away from the main channels.

As regards the geological structure of New South Wales, Professor Gregory observes that the block of older rocks was divided into two parts in Middle Palæozoic times by the great valley now occupied by the basin of the Hunter. This basin was filled with Carboniferous sediments, which were deposited upon the upturned edges of pre-existing strata. In contrast to the north and south strike of the older rocks, these Carboniferous beds strike from east to west. Referring to the pre-Carboniferous beds, he observes that Upper Ordovician, known by its graptolite fauna, is widely distributed throughout New South Wales, the limestones being full of corals, the shales yielding many trilobites and the sandstones many brachiopods.

The beds of Carboniferous age are interesting from their economical importance, for at present this colony retains its lead over Queensland in coal production. There is a section (by J. E. Carne) on page 282, across part of the Blue Mountains, where, on upturned slates and quartzites, said to be Devonian, beds of Permo-Carboniferous age (Upper Marine and Upper Coal-measures) are succeeded by beds of Triassic age. This section is also remarkable as showing the weird sculpture of the district in question. A boring in Sydney harbour shows coal-bearing beds at a depth of 3,000 feet; hence the available coal-area is not to be judged merely by the extent of the Carboniferous outcrop. On p. 315 the full development of the Permo-Carboniferous rocks (classified by Professor David) is given as follows:—

	Thickness. Feet.
1. Upper or Newcastle Coal-measures, containing an aggregate of about 100 feet of coal	1,150
2. Dempsey Series: fresh-water beds, containing no productive coal; thins out in some directions	2,000
3. Middle (East Maitland) Coal-measures, with about 40 feet of coal	570
4. Upper Marine Series; characterized by *Productus brachythærus*	5,000
5. Lower or Greta Coal-measures, with about 20 feet of coal ...	130
6. Lower Marine Series, with *Eurydesma cordata*	4,800
	13,650

The Mesozoic deposits of New South Wales include representatives of the Triassic, Jurassic, and Cretaceous systems. The fossil plants of the Hawkesbury Series (Triassic) are different to the *Glossopteris* fauna of the Permo-Carboniferous. There is no good development of Jurassics. The Cretaceous beds are divided into two series—the Rolling Downs formation, which underlies the Darling Plains and is regarded as Lower Cretaceous; the 'Desert Sandstone' contains the bones of *Cimoliosaurus*, sometimes converted into precious opal, and is regarded as Upper Cretaceous. Tertiary volcanic rocks have a wide distribution.

Queensland.—The metamorphic rocks and the schists occur in three main areas, and associated with these foliated rocks are a series of ancient plutonic masses and of other igneous rocks. All these are either Archæan or Lower Palæozoic. The Carboniferous system here is divided into five series, of which three are developed in the Bowen River Coalfield, ranging from 20½° to 26° S. lat. The Upper Bowen Beds are full of *Glossopteris* and contain many coal-seams. The coal-producing series of rocks is continued into the Mesozoic period (Trias-Jura), where *Tæniopteris* takes the place of *Glossopteris.*

Of the Cretaceous system, the lower series consists of marine clays, which constitute the Rolling Downs formation, forming the surface, or underlying nearly three-fourths of Queensland. It is of economic importance as causing the impermeable cap which keeps down the water of the Flowing Wells. The Upper Cretaceous series consists of sandstones, quartzites, etc. (containing *Glossopteris*?), which are continuous with beds of Desert Sandstone. This peculiar formation, which probably has only one-twentieth of its former extent, is partly marine, partly terrestrial, and has undergone much silicification. The Cainozoic system is mainly represented by volcanic rocks, which began to flow early in Tertiary times. The most interesting of the higher deposits of this age are some breccias, rich in the bones of extinct marsupials and birds, associated with freshwater mollusca, such as *Melania*, *Limnæa*, *Physa*, etc.; also teeth of *Ceratodus*.

Victoria.—Although this is the smallest of the states or colonies of the mainland of Australia, its geology is more complex than that of any other. The dominant fact in its geological structure is that it consists of a base of Lower Palæozoic and Archæan rocks which have been thrown into a series of folds along two lines nearly at right angles to each other. The oldest rocks are Archæan, and the Lower Palæozoics are well represented, especially in the case of Ordovician sediments, which possess a peculiar interest from the circumstance that auriferous reefs, such as those at Bendigo and Ballarat, are connected with this formation. Bendigo is situated on a northern spur of the Victorian highlands, and Ballarat on a southern spur of this mountain complex.

Gold-mining in Victoria is by far too large a subject for the present review, seeing that it has yielded something like £250,000,000 in the course of its history. There is, however, an interesting notice (Science Progress, July, 1906) by Professor Gregory, which bears on the most modern aspect of mining in this country: "Years ago Bendigo was described as exhausted, but the mining industry is still flourishing there. It shows the deepest gold-mining in the world. . . . . It was at first famous for its alluvial gravels, and then for the exceptional richness of its 'blows' of quartz, which stood up in crags, owing to the wearing away of the softer slates. The quartz 'blows' seen on the surface were soon crushed, and the miners followed them underground. This work led to the disappointing discovery that the quartz-veins, instead of continuing to unknown depths, became thinner, and soon pinched out." Ultimately it was discovered that these wedge-like reefs were found to be the lower sides of arches of vein-quartz, which were connected with arch-like foldings in the country rocks; hence the lodes were called 'saddle reefs.' It is to the systematic exploitation of these 'saddle reefs,' so well described by Professor Gregory, that the continued success of gold-mining at Bendigo is due. He then proceeds to speak of Castlemaine, where the surface-gravels were phenomenally rich, whereas the quartz-lodes have been poor. He suggests that here the gold-mines are close to intrusive granitic rocks, causing much secondary concentration. This material has been removed by denudation, forming the rich alluvial deposits, and only the roots of the gold shoots remain.

Victorian geology presents many other points of interest; and the Carboniferous system, though not rich in workable coal, possesses its own special features. Thus, he says, that the Upper Carboniferous is represented by the "famous glacial deposits and boulder-clays of Bacchus Marsh, Heathcote, Bendigo, the Lodden Valley, and Southern Gippsland. These beds are unquestionably of glacial origin, as they contain polished and ice-scratched boulders, and rest upon rock surfaces which have been ground and worn by ice-action. The boulder beds are associated in places with lake deposits, but as a whole they are stratified tills." It is unfortunate that these beds have not yielded any contemporary fossils, as it would be instructive to ascertain what the fauna and flora of this early glacial period was like. The glacial beds of Bacchus Marsh are overlaid by a series of sandstones which contain the leaves of *Gangamopteris*, and would seem to be on the horizon of the Greta or Lower Coal-measures of New South Wales. The Permo-Carboniferous deposits of New South Wales, with their rich coal-seams, have not been discovered in Victoria.

Another interesting feature of this colony or state is the enormous development of Tertiary volcanics, especially in the south-west corner. The older Victorian basalts, or lavas, are associated with Middle Cainozoic beds, and were succeeded by basalts of a later period, which have been less denuded and decomposed. Still later occurred another series of volcanic eruptions, which piled up a number of craters, even now in a fairly good state of preservation. The best exposed vent of the older basaltic eruptions is the deeply dissected stump of a volcano two miles north-west of Bacchus Marsh. Here, then, the geologist may study side by side the phenomena of Frost and Fire.

South Australia.—This is somewhat of a misnomer, seeing that the colony extends right across the continent from south to north as far as the Gulf of Carpentaria. The highlands of South Australia, clinging to the south coast, serve to connect the old Archæan plateau of Westralia with the Palæozoic highlands of eastern Australia, and in this region there is great variety of rock formation, although the Cambrian is best represented. The great physical feature of South Australia is the Lake Eyre basin. This is now usually a plain of salt lakes and salt swamps; vast floods from the Queensland hills are poured into it, and the lake for a time contains salt water, but this soon evaporates, leaving only a chain of briny water-holes. This great basin is bounded on the south by the previously mentioned South Australian highlands, and on the west by the Peak and Denison ranges, whilst the slopes towards Queensland and New South Wales on the north and east are very gradual. The clays of Cretaceous age in the Lake Eyre basin imprison vast stores of water; the fossils obtained in fragments from the numerous boreholes include Cretaceous mollusca, e.g., two species of Belemnite, *Crioceras australe*, Moore, *Pinna australis*, Hudl., etc., etc. There are also much later deposits, which may be Upper Pliocene or Pleistocene, of a deltaic character, rich in *Diprotodon*, the bones of crocodiles, giant lizards, and water-birds; but no signs of contemporary man have been found.

This seems the proper place to consider the very interesting subject of the Flowing Wells of East Central Australia, noted by Dr. Gregory in the present volume (p. 101) and also in the "Dead Heart of

Australia." Between the Western Plateau of Australia and the East Australian highlands lie the great plains of East Central Australia, which are for the most part arid, and contain little or no surface-water. But deep below the surface there are sands and shales saturated with water, which is under such high pressure that, when bores are sunk through the clays forming the top of the underground reservoir, the water rushes up the borehole to the surface and discharges as a flowing well; there are also natural outlets for this pent-up water. In 1882 Dr. R. L. Jack concluded from the geological structure of Queensland that a supply of artesian water might occur in the west of that state. A borehole was completed in 1888, a water-bearing layer being reached at a depth of 1,645 feet, when the water rose to the surface and discharged nearly 300,000 gallons a day. Since then, alike in New South Wales, in Queensland, and in South Australia, numerous 'artesian' wells have been sunk, the deepest being 5,046 feet; some of this water is warm and much of it highly saline.

The author accepts the term 'artesian' in a general sense, and observes that the rise of water in these wells has been attributed to the hydrostatic pressure of the water occurring in the same layer of rock at a higher level in the Queensland hills. It was thought, for instance, that the wells were supplied by the percolation of rain- and river-water through a porous stratum extending in a continuous layer under the clays of the Rolling Downs formation so characteristic of the central plains.

The well-water was thought to be meteoric water which had fallen on the eastern hills and was thence flowing westwards, as a subterranean river, on its way towards the southern sea. It has been proved, however, that the porous stratum in question is a limited formation quite unable to supply all the wells that have been sunk; many of them derive their water from the shales and mudstones of the Jurassic beds. In the "Dead Heart of Australia" the author has pointed out that the simple artesian theory does not explain the facts. The chemical characters of the well-waters, the thermal phenomena, the irregular distribution of the water pressure, the association of the water with various gases, and the tidal rise-and-fall of the water in some of the wells present a series of phenomena none of which agree with the hydrostatic theory. He expresses a belief that the ascent of water in these boreholes is mainly due to the tension of the included gases under the pressure of the overlying sheets of rock. Much of the water is an old accumulation, some of which may have been derived by percolation from meteoric sources; much of it is probably of plutonic origin, having risen through deep springs from the underlying rocks, and some of it may be old sea-water in the Cretaceous beds. Opinion inclines to the view that there is no fear of exhausting the artesian water, but the author believes that the existing waste is unfortunate, since the supply may not prove inexhaustible.

Professor Gregory seems to have arrived at this modified 'artesian' theory slowly and by degrees. Those who have read his interesting explanation of the hydrostatic conditions as applied to the hill-country of Queensland, in connection with the underground waters of the plains, must needs confess to a certain amount of disappointment that such elaborate calculations have only a partial and limited relation to the phenomena of the Flowing Wells as a whole. The difficulty of uniform explanation increases in proportion to the extent of country exploited, and this extent, in the case of East Central Australia, is so immense that many causes may conduce to the uprise of water in the innumerable boreholes sunk throughout this vast region. Still, the hydrostatic or ordinary artesian theory may be applicable in the majority of those cases where the well-water is fresh and of normal temperature. There seems a reasonable degree of probability that much of this water is really meteoric, and therefore perennial so long as present climatic conditions prevail. The stale waters of old seas such as the Cretaceous, or waters of 'plutonic origin,' can be of little service from an economic point of view, and therefore the waste of these is not of much consequence, though their discharge in the form of flowing wells may tend to increase the already too great salinity of the surface. No doubt it must be a sad disappointment for the Australian prospector, after spending thousands of pounds in boring thousands of feet, to obtain a mixture of salt and water for his pains. Nevertheless, such mishaps sometimes occur in the old country, as was the case recently at Lincoln, where a costly borehole sunk to a depth of slightly over 2,000 feet brought up a copious supply from the Trias, which, it was hoped, would purify itself by degrees; but at present the only use for such a genuine artesian overflow would be the establishment of warm salt-water baths in an inland city.

Westralia.—We have already seen that the immense territory included under this name consists mainly of Archæan and Old Palæozoic rocks, with a coastal fringe of newer rocks which runs from 20 to 30 miles in width ere the face of the plateau is reached. From its western edge this plateau is a broad undulating tract, mostly between 1,000 and 2,000 feet in elevation up to the confines of South Australia on the east. Except in the extreme south where the Stirling Range attains 3,640 feet, and in the far north where Mount Bruce rises to 3,800 feet, the features of the country are extremely monotonous. The main interest in the Archæan plateau centres in its mineral wealth, since all the goldfields of Westralia occur in it. Harry Page Woodward divided the Archæan rocks into six parallel belts. No. 1 forms the base of the coastal district on the west, and the greater part of this belt is covered by later deposits. No. 2 is exposed in the scarp that forms the west face of the plateau. No. 3 is the first granite belt, and is devoid of minerals. No. 4 is the first auriferous belt. No. 5 is the second granite belt. No. 6, or the second auriferous belt, is the easternmost of the series, and it is in this that the famous goldfields of Coolgardie and Kalgoorlie occur. The rocks of both auriferous belts consist mainly of schists, of which the most important is a series of amphibolites, and there are also numerous dykes of granite, diorite, and porphyrite. "Bands of the amphibolites have been so crushed that they often resemble altered slates, and others have been silicified into jasperoid, and mineralized into the rich lodes of the Kalgoorlie goldfield."

The most varied district in Westralia from a geological point of view is that of Kimberley in the extreme north-west of the state. The foundation of the Palæozoic plateau here consists of Cambrian rocks. The age of these rocks is proved by the fact that they contain worms of the genus *Saltarella*, and a trilobite which is referred to *Olenellus*; the first payable goldfield discovered in Westralia is situated in these rocks. There are also indications of Silurian beds, and the Devonian system is said to be well developed in the Kimberley district, though not indicated in the geological map (p. 104). In this region also the map shows Carboniferous rocks and large patches of Tertiary volcanics.

It is, however, in the basin of the Gascoyne River, an expansion of the western coastal strip, that the most interesting development of beds of Carboniferous age occur. In all this region they belong, in the main, to the marine limestone type of the Lower Carboniferous. These beds are rich in fossil corals and in Polyzoa of a peculiar character, such as the genus *Evactinopora*, originally described from the Lower Carboniferous of Illinois and Iowa in the United States of America. There is also an abundance of characteristic Brachiopoda, etc. Beneath the Carboniferous limestones are shales and conglomerates along with beds containing coarse boulders, some of which are considered to be of glacial origin. On the south the Irwin River Coalfield constitutes the third chief outcrop of the Carboniferous beds, and this is considered to be of Permo-Carboniferous age from the fossils associated with the coal deposits. The development is considered to be a poor one, and, so far as is known, Westralia is not likely to be a coal-producing district to any extent.

The Mesozoic and Cainozoic rocks in the coastal strip are not of particular importance, except that in some cases, when reached by bores, certain Mesozoic rocks yield abundant water through artesian wells; most of the fossils indicate a Lower Jurassic age, though there is some evidence of Lower Cretaceous. A series of Cainozoic deposits rests on the Archæan plateau of the interior; it includes vast sheets of mottled clays, ironstones, and conglomerates. These clays have yielded the bones of *Diprotodon*, and they also contain patches of lime, coal, and cement, which is sometimes rich in gold. Race and laterite are abundantly deposited on the surface.

Westralia has of late been the chief gold-producing state of Australia, as the following figures for the year 1903 will show:—

	£
Western Australia	8,777,719
Victoria	3,259,483
Queensland	2,889,813
New South Wales	1,080,029
South Australia	90,031
Total	£16,047,075

W. H. H.

MISCELLANEOUS.

Proceedings Dorset Field Club: Date of Volume II.—This volume was issued without any date on the title-page; and the question has often arisen as to the correct date. Papers which it contains are dated [1883] in the Royal Society's Catalogue. However, the evidence for the date is to be found in vol. x, p. xv. An obituary notice of the Rev. H. H. Wood says: "He dies just as the 4th volume of the Proceedings . . . . is issued to the members." He died (p. xiv) on November 3rd, 1882, so that the end of October or beginning of November, 1882, is the date of the volume in question. S. S. B.

"**Sermons in Stones.**"—In a lecture delivered before the St. John's College Natural History Society at Cambridge (printed in the *Eagle*, vol. xxviii, No. 142, March, 1907) Professor T. G. Bonney has dealt with "The Geology of the College Chapel." The present Chapel was consecrated in May, 1869. Its walls are of Ancaster and Ketton stone, and it is roofed with Collyweston 'slate'; but it includes some portions of the older chapel constructed of Barnack stone and Totternhoe stone. In various parts of the new building different materials are used for decorative and other purposes, such as the red dolomitic sandstone of Mansfield, paving-stone from Yorkshire, granite from Peterhead, serpentine from the Lizard, marble from Connemara, Devonshire, Purbeck, Derbyshire, Armagh, Belgium, and Carrara. With this wealth of materials before him, Professor Bonney has been able to preach an excellent sermon on stones, one of considerable interest, and one perhaps not unlikely to distract the minds of those who attend the College Chapel, when they learn how instructive it is as a Museum of Practical Geology.

Honours to Distinguished Men of Science.

Sir E. Ray Lankester, K.C.B.—The honour of a Knight Commander of the Bath has been bestowed by His Majesty on Professor E. Ray Lankester, F.R.S., the Director of the Natural History Departments of the British Museum, who, we regret to learn, is, at the early age of 60 years, shortly relinquishing his most interesting office. Last year he was President of the British Association at the 76th Annual Meeting held in York.

Sir A. Geikie.—"We are officially informed that the King has conferred a knighthood of the Most Honourable Order of the Bath, civil division, upon Sir Archibald Geikie, Secretary to the Royal Society. Sir Archibald Geikie, who is in his 72nd year, was the first Murchison Professor of geology and mineralogy at the University of Edinburgh, of which city he is a native. He was President of the Geological Society in 1891, of the British Association in 1892, and Director-General of the Geological Survey of the United Kingdom and Director of the Museum of Practical Geology, Jermyn Street, from 1882 till 1901. He was re-elected President of the Geological Society in February, 1906, and will deliver his Address as President at the Centenary Commemoration on September 26th."—Reprinted, *in part*, from the *Daily Chronicle*, August 10th, 1907.

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ORIGINAL ARTICLES.

I.—EVIDENCES OF A MANDIBLE OF A NEW LABYRINTHODONT FROM THE UPPER KARROO BEDS OF CAPE COLONY (*PTYCHOSPHENODON BROWNI*).

By H. G. SEELEY, F.R.S., F.G.S., King's College, London.

(PLATE XIX.)

I AM indebted to Mr. Alfred Brown, of Aliwal North, for the opportunity of describing a small fragment of a lower jaw of a Labyrinthodont which shows some unusual characters in the dentition and in the composition of the mandible (Pl. XIX, Fig. 1). Hitherto the evidence of the structure of the mandible has been imperfectly recorded in these South African reptiles.

Mr. Brown's specimen is a small transverse segment, probably from the left ramus, at some little distance behind the symphysis. This position may be indicated by an angular ridge upon the inner side, which is becoming more elevated as it extends forward. There is no suggestion of the original length of the mandible, which may have been eighteen inches. The fragment is little more than an inch and a half long. In section the jaw is subquadrate, somewhat depressed, being two inches wide and an inch and a half deep. The external surface of the bones shows no trace of sculpture. From its slightly water-worn condition the specimen (Fig. 1) was probably obtained from the reconstructed bed at the railway station at Aliwal North, which yields Theriodonts and other fossils.

The external bone is apparently vertical, traversed on the lower third by a deep longitudinal groove, in which there is a faintly marked suture. The dentary bone above the groove is slightly convex up to the alveolar margin, and shows what may be a sinuous impression above the groove. The bone below the groove, which may be infra-dentary, is well rounded on to the base.

The base is flattened, but slightly convex from side to side, and is marked by a median groove which traverses a median inferior bone defined laterally by two irregular sutures. The base of the jaw is limited towards the inner side by a slight angular ridge. The inner side is divided into upper and lower flattened areas by the median angle already referred to. There is a longitudinal suture in the middle of the upper portion of the palatal surface.

The transverse sections, back and front, are vertical and clean, practically unworn, and of similar transversely oblong form.

In the middle is an oblong central cavity (M.), which is less than an inch wide and less than half an inch deep. From it the sutures radiate which separate the constituent bones. When the specimen is examined from the external surface the only well-marked sutures are upon the base, so that on such evidence the jaw might be interpreted as formed of two bones. The narrow straight lateral line between the surangular and splenial on the inner side might pass for a crack in the specimen. Similarly, the line in the external groove between the elements of the dentary and infra-dentary might have been supposed to be the opposite side of the same fracture but for the transverse sections. These lateral conditions are found to be natural divisions when the broken ends of the fragment are examined. More or less serrated and angulated sutures are marked by lines of black matrix as represented in the figure (see Pl. XIX, Fig. 1). They are not all followed with equal facility, and the external dentary bone is obscurely divided into superior and inferior elements by suture, for the division is less evident at the other fractured end. The complicated suture between the internal splint bone, which I regard as the splenial, and the two bones on which it rests is also less distinct on the posterior fracture in this specimen, where the surface is more weathered, but may be followed with a magnifying-glass. The most interesting suture is the vertical division, showing that two distinct parallel bones support the teeth in two parallel rows, of which the outer row is rather the longer.

The external dentary bone carries five teeth, which are close set. Their crowns are broken and show no trace of a pulp cavity. The basal attachment is four times as wide as long from front to back. The attachment of the teeth is of a pleurodont type, for the external alveolar border rises fully half an inch above the rounded internal exposures of the crowns; and on their inner side the dentary bone rises as an oblique rounded strip from the groove in which these teeth are imbedded. Both front and back fractures pass through the bases of crowns of teeth. In the middle of the base of the tooth, on what may be the posterior fracture, the crown descends in a small short oblong portion into a shallow socket, and shows the same folded structure as the rest of the tooth. The smooth surfaces of the teeth are marked with fine parallel vertical grooves upon the enamel, which vary in depth on the several teeth. Each crown decreases in size as it ascends, by becoming narrower from within outward.

The bone which abuts against the dentary above the Meckelian vacuity on the inner side of the jaw is regarded as the surangular bone, and beneath it is the angular bone. The lateral junction between these bones is hidden by the splint-like covering of the splenial. The determination of these elements rests upon the sutures shown in the transverse sections. But if there is an infra-dentary, there may also be an infra-angular; and these elements may be upper and lower divisions of the angular bone.

The upper or surangular bone is small compared with the dentary, to which it is parallel and internal. At its suture with the dentary bone it rises above the level of the dentary on the superior dentigerous surface, where it is roughened and vascular, forming a supporting outer ledge for the teeth which it carries, which is of the same kind as the external elevated alveolar border of the dentary bone. The teeth, however, are smaller; they are not so close set in this specimen; each has a transversely ovate base, and is implanted in a shallow conical pit or socket, which the base of the tooth does not completely fill, for a groove extends round the base of the inner side of the tooth. The base is invested with an osseous cement, above which the crown shows vertical grooves of the same type as are seen upon the row of teeth in the dentary bone. At one end of the specimen a fracture passes through the base of a tooth, and shows the same folded structure in these teeth as in the parallel dentary tooth; next is a large empty socket, the base of which is not clean from matrix; this is followed by a broken tooth in position; and lastly, after an interval, the terminal fracture passes through the middle of a clean empty conical socket. The teeth of this inner row appear to diminish in size as they extend backward.

As the teeth are broken to the level of the alveolar margin of the dentary I availed myself of the opportunity to obtain a transverse section of a portion of a tooth on the dentary bone at the level of the alveolar border where the tooth is ovate. In microscopic enlargement the labyrinthic structure is much less folded and simpler than in any other tooth from these rocks which I have examined (Pl. XIX, Fig. 2).

In the Museum of the University of Munich a second specimen of the mandible of the same species is preserved, collected at Middelburg in Cape Colony. The late Professor K. v. Zittel placed it in my hands to complete this description. The Munich fossil is a fragment from the right ramus of the mandible, two and three-quarter inches long. It exactly corresponds in its position in the jaw with the fragment of the left ramus from Aliwal North. The anterior fracture is oblique, the posterior fracture is vertical. The sutures are not shown upon the black bone of these ends. The fossil indicates a long narrow skull, with a short mandibular symphysis (Pl. XIX, Figs. 3, 4).

The Middelburg specimen is from a soft matrix, which has been sufficiently removed to show the forms of the teeth and their implantation. The dentary series of teeth gives evidence of nine teeth in a length of two and seven-tenths inches, so that each tooth occupies three-tenths of an inch, as in the other specimen, and the basal attachment is eight to nine-tenths of an inch wide. Five teeth are lost, and as these are consecutive the bases are seen to be divided from each other transversely by ridges, forming shallow sockets (Fig. 4), rather more pronounced than those sometimes seen in the not dissimilar but deeper groove which carries the teeth in *Ichthyosaurus*.

The crowns are better preserved, and have a singularly compressed, sharp, triangular, wedge-shaped aspect, as though used for catching fish. They are flattened laterally, rounded on the narrow outer and inner aspects, which are straight and converge upward to a sharp point. Each of these wedge-shaped teeth was about one inch and a quarter long, but only one shows the extremity of the crown. Seen from the end, the contour of a tooth is not unlike a large longitudinally grooved vomerine tooth of *Labyrinthodon*; it curves slightly inward (Pl. XIX, Fig. 2). On the inner side of the teeth the dentary bone rises in the same smooth rounded surface as in the other fossil, but externally an osseous cement appears to extend on to the tooth from the alveolar border.

The second inner row of teeth originates just behind the anterior fracture, and includes indications of about twelve close-set teeth, carried in a groove which gradually widens as it extends backward. The teeth are smaller than the dentary series, but the crowns resemble them in all ways, being similarly compressed from front to back and wedge-shaped. The early crowns are broken, and several are missing from their sockets. These teeth are implanted in the bone which extends down the jaw between the dentary bone and the splenial, which is probably the surangular bone. Below the suture the splenial bone is rounded and shows no trace of the angular condition of the other specimen. The base of the jaw is less flattened, traversed by three rather stronger little ridges; but the two sutures which are so marked a feature of the specimen from Aliwal North are not visible. The external lateral groove on the dentary bone becomes a circular tubular canal as it extends backward, running below the teeth. This groove is characteristic of Ichthyosaurs. A fine suture appears to run down its length, as in the fragment from Aliwal North separating the lower half of the bone as infra-dentary. The presence of such an ossification is an interesting approximation to the condition in Holoptychian fishes, in which Dr. Traquair's specimens show two parallel rows of teeth; and those fishes have their tooth substance folded in a way that approximates to Labyrinthodonts, and especially to this fossil.

The presence of these five bones in the mandible, which does not include the articular bone or the coronoid in the specimens preserved, appears to show that some South African Labyrinthodonts include seven bones in each ramus of the mandible. This character may not vary the general reptilian affinities of the skull, but appears to be a departure from the reptilian type in the mandible, which may approximate towards a lower type. The additional bone in the mandible is quite distinct from that described by Dr. Branson.

EXPLANATION OF PLATE XIX.

Fig. 1.—Transverse anterior fracture of ramus of mandible in Aliwal North specimen, showing bones about the Meckel cartilage cavity (M.); dentary and infra-dentary externally, surangular and angular internally, overlapped by the splenial bone on the inner side. *a*, anterior end.

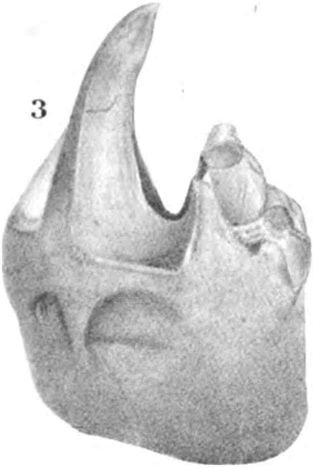
,, 2.—Transverse section, much enlarged, of part of a dentary tooth of the same specimen. The section was prepared by Professor Chapman, of Melbourne, and photographed by A. Campion, Esq., in the metallurgical laboratory, Coopers Hill.

,, 3.—End view of the Middelburg specimen in the Munich University Museum, showing an entire external tooth, with natural curvature of the crown.

,, 4.—The same specimen seen from above, showing a succession of empty tooth sockets on the mandible.

Figs. 1, 3, and 4 are of the natural size.

3



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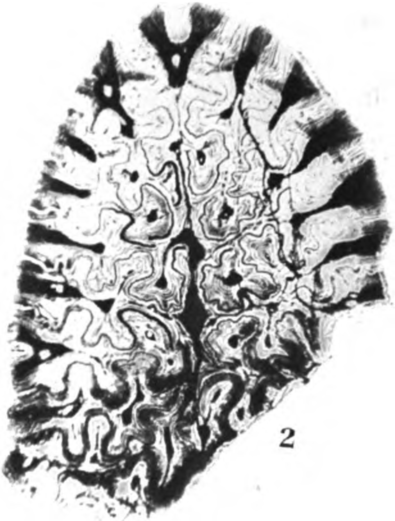

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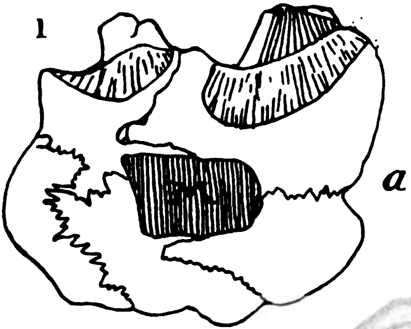

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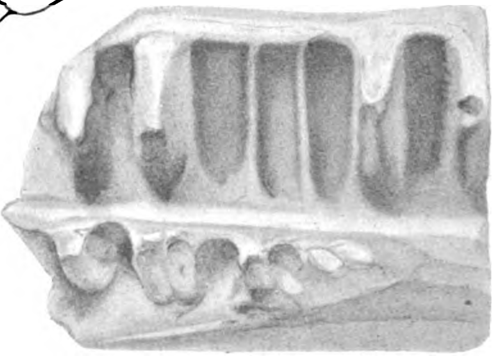

Labyrinthodont Reptilian remains from the Upper Karroo Beds of Cape Colony.

II.—NATHORST'S USE OF COLLODION IMPRINTS IN THE STUDY OF FOSSIL PLANTS.

By F. A. BATHER, M.A., D.Sc., F.G.S., British Museum (Natural History).

THE following note is based on two papers by Professor A. G. Nathorst[1] and on further details which he has kindly communicated by letter. For the loan of the block (Fig. 1) thanks are due to Dr. H. Munthe, Secretary of Geologiska Föreningen i Stockholm.

By the term 'collodion imprint' is meant the impression of any surface on a thin film of collodion. Such an impression is obtained by letting a drop or two of collodion dissolved in ether fall on the surface to be copied. The ether evaporates rapidly, so that in two or three minutes the film is hard. If it does not of its own accord come loose at the corners, it is easily raised by a needle or sharp knife. It is then lifted on to a glass microscope-slide and preserved dry under a cover-slip held in position by gummed strips of paper or by Canada balsam. When the imprint is very sharp, the film can, if desired, be preserved in glycerine-jelly without its distinctness being greatly affected. Some films may be less successful than others, and some may curl too much, so that it is as well to take more than one imprint. In any case it is advisable to throw away the first made, since it usually retains some dust from the surface of the object, whereas following films will be free from this. If the collodion solution is too thick it may be thinned by the addition of ether or of ether and alcohol. The thicker the solution, the more liable is it to air-bubbles; the thinner solution gives a thinner and clearer film, which may sometimes be an advantage, also it takes longer to dry, which is of no great consequence. No definite prescription can be given as to thickness; one must find out for oneself the kind of solution most suitable for the objects with which one is dealing.

The film placed on the slide is examined under the microscope by transmitted light. Since the film is thicker over the depressions of the original surface, it appears darker over these tracts, so that the structure is easily seen. In fact, quite high powers of the microscope can be used, and photomicrographs taken. Professor Nathorst reproduces one such photograph with a magnification of 500 diameters (Fig. 1). The illumination of the film should not be directly from below, but oblique, the mirror being shifted until the best effect is obtained.

Such collodion films have long been used in the measurement of microscopic objects, especially in the preparation of copies of the eye-piece-micrometer in order to determine the magnifying power of the microscope. They have also been employed by botanists to copy the cuticular surface of living leaves for the study of physiological processes.[2] L. Jost also briefly stated in 1902 that he had successfully applied the method to the study of the surface structure in fossil plants. It is, however, to Professor Nathorst that we are indebted for the first publication of results obtained by it in the study of fossils,[1] and for the first account of its advantages in palæobotany. From the many instances of the successful use of this method given by Professor Nathorst a few will now be noticed.

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[1] "Kollodiumaftryck såsom hjälpmedel vid undersökning af fossila växter": Geol. Fören. Förhandl., Bd. xxix, pp. 221–227, April, 1907. "Über die Anwendung von Kollodiumabdrücken bei der Untersuchung fossiler Pflanzen": Arkiv för Botanik, Bd. vii, No. 4, 8 pp., 1 pl., August, 1907.

[2] L. Buscalioni e G. Pollacci: "L'applicazione delle pellicole di Collodio allo studio di alcuni processi fisiologici nelle piante ed in particolar modo alla Traspirazioni," and "Ulteriori ricerche sull' applicazione, etc.": Atti dell' Istituto botanico dell' Università di Pavia, ser. II, vol. vii, Milan, 1902.

The first attempt was naturally one to study well-preserved cuticles of carbonised leaves. In the case of *Baiera spectabilis*, however, a ginkgo form from the Coal-measures of Scania, the attempt was quite unsuccessful. In the case of some carbonised leaves of dicotyledons it was occasionally possible to observe a suggestion of the contours of the elongate cells over the veins and their branches; but this was of no particular interest.

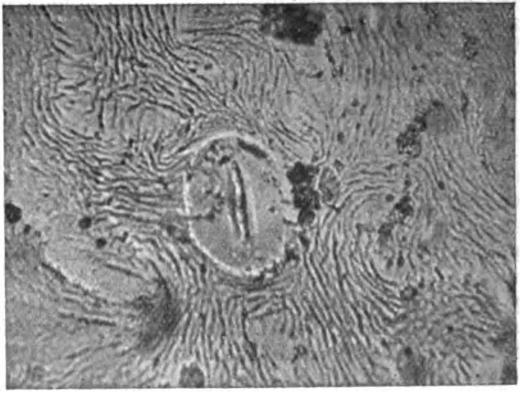

Fig. 1.—Microphotograph (× 500 diam.) of a collodion film showing a stoma and the outer sculpture of the cell-membrane on the upper surface of a leaf of *Tussilago farfara* in the calcareous tufa of Benestad in Scania. (Lent by Geologiska Föreningen i Stockholm.)

Better results were obtained with the sporangia of fossil ferns. In his description of *Dictyophyllum exile* last year, Professor Nathorst was able to publish photographs of those organs enlarged 8 diameters; but the use of films enabled him to study the same bodies with the microscope, and he now reproduces a photograph enlarged 45 diameters. Fossil sporangia are best studied by this method when they have a well-developed annulus, but good imprints have also been taken from the sporangia of *Todites Williamsoni* in which this is not the case.

Occasionally some sporangia adhere to the collodion film and are pulled away with it. This was the case with a specimen of *Thaumatopteris Schenki*. By laying the film in Eau de Javelle the walls of the sporangia were dissolved, and the spores, adhering to the film, exposed in their undisturbed position (*op. cit. ult.*, 1907, pl. ii, fig. 18).

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[1] "Ueber *Thaumatopteris Schenki* Nath.": K. Sv. Vetenskaps-Akad. Handl., xlii, No. 3, 1907.

Fossil wood is readily studied by this method, especially when silicified. In this case the broken surfaces generally are transverse, radial, and tangential, or at any rate such surfaces can be readily exposed by a few blows of the hammer. Collodion imprints of these are almost equal to thin sections taken in the same directions, and, in coniferous wood for example, show the medullary rays, the tracheids, and the bordered pits with remarkable distinctness. Imprints from a silicified fragment of *Cupressinoxylon*, originally described by Conwentz in 1891, show every cell in the clearest manner even under high powers of the microscope. Wood from Brown Coal, if well preserved, also furnishes good imprints, especially of surfaces in a longitudinal direction.

Plant-remains preserved in the finer sediments of chemical origin, such as calcareous tufa, the Mesozoic silicious rocks of Franz Josef's Land, and some clay ironstones, have also yielded good results. Thus a piece of a Conifer from the tufa of Benestad in Scania gave imprints showing all the points above mentioned. Leaves in tufa have not always been completely embedded before decay set in, and may not always furnish serviceable preparations. A very successful imprint, was, however, made from a leaf in the Scanian tufa, referred by C. Kurck in 1901 to *Tussilago farfara.* This preparation showed the outlines of the epidermis-cells, the hair-scars, the stomata, and the peculiar streakiness of the outer cell-wall, even under a magnification of 500 diameters and upwards (Fig. 1). Thus Kurck's determination was fully confirmed. The imprints taken from these tufaceous fossils must sometimes be cleaned by acid from the adherent calcareous particles.

As regards leaves in the silicious rock from Franz Josef's Land, it is enough to mention that Professor Nathorst now publishes photographs of films showing the structure of the epidermis-cells and the stomata in *Desmiophyllum*, features that Solms Laubach, who studied the same specimens in 1904 with the aid of thin sections, had not been able to discern.

The advantages of the method as applied to fossil plants may now be summed up. It is not claimed that collodion imprints can altogether supersede thin sections, although, as the last instance shows, there may be cases in which they reveal even more than the sections. But there are many cases in which either time or the state of preservation of the specimen, or perhaps its owner, do not permit of thin sections being made; films then form an admirable substitute. It may often be a saving of time to work over a collection rapidly by this means, sorting fragments into their genera, and selecting for further treatment those that seem to promise best results. Why, it may be asked, not put the specimens directly under the microscope? Because in some cases they are much too large to be so handled, and in any case the structures cannot so easily be seen by reflected light. The last reason reminds one how readily these films can be photographed, although even the excellent photographs reproduced by Professor Nathorst cannot, as he points out, reveal the structure so well as the films themselves when studied with a varying focus. But this suggests another advantage: the films are easily made, and can be repeated to almost any extent without damaging the specimen, so that it would be a simple matter for any worker to send a set to all his correspondents, or better still to the chief museums.

Professor Nathorst suggests that the method may also prove of service to zoologists, whether neontologists or palæontologists. Certainly it might sometimes enable one to study delicate ornament and to obtain photographs of it with greater ease, especially when the specimen itself is of a dark colour or irregularly spotted with colour. Some of the minuter Bryozoa, or colonial Hydrozoa, or Stromatopores, might perhaps lend themselves to this treatment. I have myself laid in a stock of collodion solution and intend to use the method as occasion offers. Meanwhile it is hoped that the publication of this note will direct the attention of other workers in this country to what promises to be a valuable aid to the palæontologist.

III.—RECESSION OF THE NIAGARA FALLS.[1]

By Professor J. W. SPENCER, A.M., Ph.D.

FOR many years Niagara Falls and the Great Lakes of America have been special subjects of my researches. These at last have been completed under the Commission from Dr. Robert Bell, acting Director of the Geological Survey of Canada, and later of Mr. A. P. Low, Director, with results beyond anticipation. These were obtained through precise instrumental measurements, borings, and soundings, not hitherto undertaken.

My recent survey of the crest-line (1904–5), compared with that of Professor James Hall, 1842, shows the mean rate of recession to have been 4·2 feet a year, with the average breadth of the gorge produced by the falls being 1200 feet. But a longer record (agreeing with the more recent) has been found by Mr. James Wilson and myself in discovering the position of the Falls in 1678, from the crude description and picture made by Father Hennepin at that time. Between 1890 and 1905 the rate of greater recession diminished.

I succeeded in making soundings under the Falls and throughout the Gorge by the use of Tanner-Blish self-registering tubes, depending upon the hydrostatic pressure, as the current was too strong for the use of an ordinary line. At the Whirlpool, and at some other places, it was necessary to work from a cable swung across the Gorge. Under the Falls themselves, the sounding tubes were inserted in a specially designed buoy which the force of the Fall drove down to the rocks, that had collapsed beneath the Falls themselves. These were reached at 72 feet, while the floor of the river beyond varied from 84 to 100 feet below the surface of the river. Farther down, there was a lateral inner gorge, reaching to 192 feet, which could not have been produced by the present descent of the Falls. An explanation of this, however, was found.

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[1] Read before the British Association for the Advancement of Science, Section E (Geography), Leicester, August, 1907. Abstract.

The river at the Whirlpool was measured to a depth of 126 feet, but this was not quite in the middle of the current, where the depth is supposed to be 14 feet greater. Below the Whirlpool the river is shallower. From a short distance below the Falls extending to the Whirlpool, the bottom of the channel has a depth of about 90 feet below the level of Lake Ontario.

At points a short distance within the end of the gorge and also beyond, a narrow, deep, inner channel, reaching to about 180 feet below the level of Lake Ontario, was discovered. This established the fact that the aggregate height of the different parts of Niagara Falls was more than 500 feet

A terrace formed upon the birth of the Falls shows that they were only 35 feet high. The present height is 158 feet, with a descent of the different parts of Niagara River reaching 326 feet.

During the long, earlier history of Niagara, there were at first two, and later, three, separate cataracts. The upper two united when the Falls had receded about three miles; the third joined the others later, but it had no effect on the recession of the main Falls, as it was soon reduced in height by the backing of the waters of Lake Ontario.

Until this time, when the Falls had passed the point of union by only 600 feet, the volume of the river was 15 per cent. of the modern size. Now it was increased to 100 per cent., breaking through the floor of the cañon to a depth of 135 feet, which the united cataracts had not been able to do before the increase in the volume of the Falls. This augmentation resulted from the accession of the drainage of Lakes Huron, Michigan, and Superior, which formerly drained to the north-east, and only now joined the Lake Erie discharge, for until this time Niagara received only the drainage of Lake Erie. This change was due to a tilting of the earth's crust, which culminated only 3,500 years ago.

The Upper Rapids are due to the river recently reopening a buried valley and descending over its eastern slope. This valley, however, did not trend northward, but southward. Accordingly, the Upper Rapids have had little to do with the recession of the Falls.

Thus it appears that the rate of recession has been modified by changes of volume and of height. These features, and the character of the rock-formation, as well as the buried valleys, I now know for every furlong which the Falls have receded. If we apply the laws of erosion to these changing features the result will indicate that the time required for the recession of the first three miles was 35,000 years; but for the last four miles only 3,500 years, which gives a total age of 39,000 years. As all the changing conditions are now known, it appears that the probable error does not exceed 10 per cent. This is the only computation of the age of the Falls which has been made upon measurements of all the changes in the physics of Niagara Falls, to which no other has had access.

Almost all of the physical changes in the history of Niagara Falls have been made by the writer, at different times. These, with the newly-found features, have now been brought together for the first time, and will form a monograph of the Geological Survey of Canada.

IV.—THE ROTIFORM BRYOZOA OF THE ISLE OF WIGHT.

By J. W. GREGORY, D.Sc., F.R.S., F.G.S.

A SMALL fossil with a wheel-shaped body borne on a narrow stem has long been known from the base of the *Holaster planus* zone in the Isle of Wight. It has been recognized as one of the Bryozoa, but has not been described, although once recorded as "near *Defrancia diadema*, Hag."[1] It has also been recorded by Dr. A. W. Rowe as "the beautiful little rotiform Bryozoon."[2]

The following diagnosis has been lying unpublished for eight years in the manuscript of the second volume of the Catalogue of Cretaceous Bryozoa in the British Museum. A preliminary account of the species is now issued, as the name is wanted for reference in the course of Dr. A. W. Rowe's forthcoming memoir on the Chalk of the Isle of Wight. A fuller account of the species with illustrations, on plates drawn in 1900, will be given in the Catalogue, which it is hoped will be issued during this Winter.

BICAVEA ROTAFORMIS,[3] n.sp.

Diagnosis.—Zoarium simple or compound, with a narrow cylindrical stem, attached in a circular concavity in the lower part of the body. The body of the zoarium is discoid, or wheel-shaped, and has on the margin a series of vertical radial projections like cog-wheels. The cogs usually project for a distance nearly equal to the radius of the disc. The cogs may be prolonged at their upper, outer corner into spike-like fasciculi. The upper surface between the bases of the fasciculi is depressed, and occupied by the small, crowded, irregular apertures of the intermediate, subordinate zoœcia. Stems appear solid and imperforate, as they are covered by a lamina, which is fluted vertically or wrinkled horizontally. Two zoaria may arise from one stem, or several zoaria may arise from a stolon.

Dimensions.	B.M. D. 2297.	B.M. D. 2296.
Diameter of body, central disc	3 mm.	3·5–3·75 mm.
Diameter of body, including projections... ...	5 ,,	6–7 mm.
Length of stem	2 ,,	—
Diameter of stem	·8–1 mm.	1 mm.
Zoœcia, diameter	—	·15–·17 mm.
Zoœcia, diameter of aperture	·08 mm.	·08–·1 mm.
Number of fasciculi	—	8–9

Distribution.—Dr. Rowe has kindly given me the following list of localities. The horizon is always the base of the *Holaster planus* zone:—Dorset: Mupe Bay. Isle of Wight: Military Road, Freshwater; Pit No. 13, Shalcombe Down; Pits Nos. 19 and 20, Arreton Down; Pit No. 37, Brading Down; Pit No. 51, Carisbrooke; and at Compton Bay and Culver Cliff.

Affinities.—The nearest allies of this species are some specimens from the Danian Chalk of Faxoe described as *Radiopora urnula*,[4] var. *stipitata*, by Pergens & Meunier in 1887; the authors divided that species into three varieties, of which the form *stipitata* has a narrow stem and discoid head like the English specimens. Some workers at Bryozoa would no doubt include the Danian, the French Maastrichtian, and the British Turonian varieties as all members of one species, which would then have the name *B. urnula* (d'Orb.).[1] But the differences between the specimens from these three horizons seem adequate for their specific separation. The *B. urnula*, the type species of the genus, has a vasiform body, which is convex below and passes gradually into the short stem, while the apertures of the zoœcia are on tufts or radial keel-like plates projecting above the body. *B. rotaformis*, the oldest representative of the genus, has a wheel-shaped body on a narrow stem, and the apertures are on vertical teeth on the sides of the body. The Danian forms are very variable in form; the stem is longer and narrower than in *B. urnula*, but it still passes by a gradual expansion into the body; the usual form of the zoarium is more piriform than in *B. rotaformis*. Further differences are that in the Danian forms the stem is perforate, and the apertures of the zoœcia open on ridges which project but slightly from the disc; in one specimen of var. *stipitata* one of the ridges projects upwards as one of the spine-like processes so characteristic of the genus. Though *B. rotaformis* is variable, the lower side of the body is apparently always concave, whereas in the Danian forms—which I regard as a new species with the name *B. pergensi*—and in *B. urnula* the base is always concave. Both Dr. Rowe and Mr. C. D. Sherborn, who have collected a considerable number of specimens of *B. rotaformis*, tell me that they have not seen one with a vasiform body, and my more limited experience has been the same.

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[1] H. W. Bristow: "Geology of the Isle of Wight," 2nd ed., 1889, p. 272.

[2] A. W. Rowe: "The Zones of the White Chalk of the English Coast.—II. Dorset": Proc. Geol. Assoc., vol. xvii, pt. 1, 1901, pp. 23, 46.

[3] Shaped like a cog-wheel.

[4] *Radiopora urnula*, Pergens & Meunier: Bry. gar. Faxe: Ann. Soc. mal. Belg., vol. xxi, pp. 224–226, pl. ix, figs. 1–5; pl. x, fig. 6.

V.—ON AN AFRICAN OCCURRENCE OF FOSSIL MAMMALIA ASSOCIATED WITH STONE IMPLEMENTS.

By F. P. MENNELL, F.G.S., and E. C. CHUBB, F.Z.S., of the Rhodesia Museum, Bulawayo.

STONE implements have long been known to occur in South Africa, but nearly all the recorded discoveries have, until quite recently, been made at the Cape. Indeed, it is only lately that the subject has attracted much attention, and that the circumstances of their occurrence have been at all fully investigated. Even now there is little precise information on the point, and yet it is essential to the solution of the problems they present. For, as one of us has previously pointed out,[2] in attempting to ascribe to their proper source the stone implements found in South Africa, we are confronted with difficulties that are unknown in Europe. Not only has the country been inhabited down to the present day by tribes like the 'Bushmen' unacquainted with the working of metals, and whose origin probably long antedates the earliest Egyptian civilisation, but we find stone still employed by the Bantu for certain purposes, and in Rhodesia the question is still further complicated by the existence of numerous ruins built by an unknown race possessing a considerable degree of barbaric culture, but still employing primitive types of stone implements. Geological evidence is therefore more than usually necessary, but, when there is any, it is frequently very ambiguous owing to the characters of the superficial deposits. More often than not it is altogether lacking, the great majority of the implements found having been picked up on the surface. Colonel Feilden some time ago pointed out the probability of certain of the Zambezi implements being of vast antiquity,[1] and one of us had already formed a similar opinion in the course of a brief visit to the Victoria Falls. It is also probable that in other parts of Rhodesia the high-level laterites, corresponding to the plateau gravels of rivers like the Thames, are the source of the implements found where they occur, but, as in the case of the Zambezi, we are unable to afford absolute proof.

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[1] *Fasciculipora urnula*, d'Orbigny, 1850: Prod. Pal., vol. ii, p. 268. *Bicavea urnula*, d'Orbigny: Bry. Crét.: Pal. Franç., vol. v, 1854, p. 956, pl. 776, figs. 1–2.

[2] See Fourth Annual Report of the Rhodesia Museum (1904), which contains the first published descriptions of Rhodesian stone implements.

Many of the Rhodesian implements can with considerable confidence be ascribed to the Bushmen, from their being found in caves decorated with the well-known paintings of that primitive race. These paintings cannot usually be deemed of any great antiquity, but the fact that an implement is Bushman does not in any case prevent its being of considerable age, and it is not even any guarantee that it is not fully as ancient as the European palæoliths. And it need hardly be pointed out that all cave implements are not necessarily Bushman, as the caves may have had different occupants at different periods. But for conclusive proofs of antiquity, it is necessary for the relics of human occupation to be associated with animal remains. Such remains have so far been exceedingly rare in Africa, and the recent discovery in Northern Rhodesia of fossil mammalian bones which proved to be associated with stone implements is therefore of great interest. Several casual references to the matter have already appeared in print, and at the risk of being somewhat premature in our conclusions it has seemed advisable to publish the following notes on the occurrence so as to place on record what has been definitely ascertained up to the present. Our investigations have been chiefly based on specimens in the Rhodesia Museum presented by the Broken Hill Company, Mr. Franklin White, Mr. Marshall Hole, and others, as well as on other material for the opportunity of examining which we are indebted to Mr. White and Mr. F. G. Colvile.

The Rhodesian Broken Hill Mine is situated about 150 miles north of the Kafue River in North-Western Rhodesia. It contains extensive zinc and lead deposits, which have a prominent outcrop in the shape of two small hills or 'kopjes' rising out of a 'vlei,' or swampy flat. The surrounding country is chiefly limestone, which is associated, in proximity to the ore-body, with schistose rocks, evidently altered sandy and shaly sediments, together with crushed bands of the limestone itself. There is granite not many miles distant, but the ores do not appear to have any direct connection with an igneous rock; they seem rather to be related to faulting and shearing of the limestone at its junction with the schists. Surface specimens of the limestone are usually somewhat coarsely crystalline, and white or grey in colour, with few impurities save quartz. Lower down in the workings they are often black or reddish in colour, and closely resemble the Carboniferous Limestone of Somersetshire. Under the microscope, however, they differ *in toto*, having a foliated structure in even the most compact-looking specimens. It is probable, therefore, that the sugary appearance of the outcropping rock is due to some form of surface alteration. It cannot be attributed to pressure or contact metamorphism, as it would in that case be just as apparent below ground as it is above. The limestone is highly magnesian and sometimes approaches a true dolomite in composition. No definite silicate minerals can be detected under the microscope.

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[1] *Nature*, vol. lxxiii, p. 77.

The feature of the ore-body with which we are now chiefly concerned is the extraordinary accumulation of mammalian bones in No. 1 Kopje. Beautifully crystallised phosphatic minerals have also been found in No. 2 Kopje, but although it would seem a natural inference that they are due to the interaction of the metalliferous solutions with the lime phosphate of bones, none of the latter have been met with. The amount of bones in No. 1 Kopje is enormous. They occur in the central part of the kopje and almost continuously beneath it, below the level of the surrounding flats. It would appear that the bone deposits represent the infilling of a large cavern in the limestone, perhaps with a kind of swallow-hole leading down from the top of the kopje, though there is no actual opening at the present time. It is difficult from the data at present available to determine with any certainty the relative ages of the different layers of bones, but their accumulation must have taken a very long period of time. There are masses of bones almost free from other substances, and there are interspersed muddy layers containing zinc compounds, but free from bones. Much of the material, however, which shows no large bones, yields on disintegration innumerable bones of rats, shrews, birds, etc. The bones are in nearly all cases partly or wholly converted into zinc phosphate (hopeite?). They are therefore truly fossil, the organic matter having disappeared, and having been completely replaced by mineral substances. Vughs in the deposit are often lined with magnificent crystals of the rare mineral hopeite, and they also show at times more or less dendritic coatings of a substance which at first was taken for amorphous zinc phosphate, but which is rich in vanadium, and may really be a calcium vanadate. The new triclinic zinc phosphate 'tarbuttite' occurs in No. 2 Kopje, with cerussite, hemimorphite, hopeite, pyromorphite, and vanadinite or descloizite, and does not seem to be found in the bone deposit.

The bones make up vast accumulations of isolated broken fragments. Whole bones are the rarest exceptions, and are exceedingly difficult to extract even when discovered. There never appear to be a number of bones belonging to the same animal occurring together, as would be the case if they had died naturally on the spot, or been accidentally engulfed, in the way suggested for the well-known occurrence at the Winnats, Castleton, Derbyshire. It seems certain that the deposits as a whole represent the materials accumulated during alternating occupations of the original cavern by animals and human beings, with intervening periods when the cave was untenanted owing probably to flooding with water. The animal occupants were such as are found together in the Rhodesian caves of the present day, namely, hyænas and porcupines, no doubt accompanied by owls and bats. Some of the bones show signs of having been gnawed by hyænas, and there can be little doubt that many of them were dragged into the place when it served as a hyæna den. Most of the smaller bones are probably to be accounted for in a somewhat similar fashion, the rats, shrews, etc., having formed the prey of owls, and the bones having been ejected in the usual pellets after the birds had assimilated the more digestible portions of the bodies. An examination of modern owl pellets entirely confirms this view, as these latter show the same predominance of head and leg bones as do the washings of the Broken Hill deposit. As usual with mammalian remains, lower jaws are particularly prominent. Those parts of the deposit which contain implements no doubt owe their accumulation in great part at least to human agency, the bones being relics of the food supply of the ancient inhabitants. It may at once be stated that the contemporaneity of the implements and bones is entirely beyond question. Masses of the deposit full of bones when disintegrated by soaking in water, are found to contain embedded implements. These latter are of a rude order and mostly made of quartz, owing of course to the absence of any more suitable material in the vicinity. There seems to be a strong prejudice in England against the genuineness of implements made of quartz, and it may therefore be well to emphasize the fact that some are made of chert brought from a distance, and it may also be well to point out that quartz is a very common material for Bushman implements, which the Broken Hill ones much resemble. Knives, scrapers, and grooved scrapers are the common types. Some of the bones show indications of having been cut previously to their mineralisation, as if to make implements, though no finished bone implements have so far been brought to light. One tibia of a moderate-sized ungulate in the Rhodesia Museum has had a nearly circular hole made in it prior to its replacement by zinc salts. This may be attributed to a wound from an arrow of the Bushman type, or it may have been bored with a view to making an implement or ornament: in either case it must be due to human agency.

With regard to the age of the deposit, it must represent a long period of time in all, but it will be noted from the subjoined list that nearly all the bones appear to be referable without much doubt to recent species inhabiting the country at the present day. It is probable, however, that some may represent closely allied but really ancestral forms, and this certainly appears to be the case with the species of *Diceros* (rhinoceros) of which two well-preserved bones are now in the Rhodesia Museum. It is unfortunate that we are not in possession of skulls or teeth of this animal, but we think there can be little doubt as to its being new, and it has therefore been thought well to give it a name for convenient future reference.

The mineral condition of the bones and the obvious changes in the physical features of the locality since the deposit was formed are entirely in accord with the idea of its being of very great age from an anthropological point of view. There consequently appears to be every justification for our belief that the evidence affords the strongest presumption of the great antiquity of man in this part of the world, and that further investigations, which we hope shortly to undertake, will reveal even more convincing proof on this head.

LIST OF VERTEBRATE REMAINS.

[By E. C. Chubb.]

The following is a list of the vertebrates represented by teeth or bones, and identified as accurately as is possible with the scanty material at my disposal for comparison. "R.M." after a description indicates a specimen in the Rhodesia Museum.

MAMMALIA.

Insectivora.

An almost complete skull, two or three upper jaws, and numerous lower jaws of shrews. (R.M.)

Carnivora.

Felis leo, Linn. A right ramus and a few odd teeth.

Felis spp. The canine of an animal about the size of a leopard, and one about the size of *Felis ocreata*. Also two lower jaws apparently belonging to *Felis serval*.

Hyæna sp. A right ramus, belongs to a hyæna, but it does not agree exactly with *H. crocuta*. (R.M.)

Viverridæ. The right ramus of a member of this family about the size of a large genet.

Rodentia.

Tatera sp. Several upper and lower jaws. (R.M.)

Otomys sp. A number of lower jaws showing the characteristic laminated molars and grooved incisors. There are also one or two odd incisors and molars. (R.M.)

Mus spp. Great numbers of lower jaws and a few portions of upper jaws belonging to several different-sized species. (R.M.)

Bathyergidæ. A right ramus, without teeth, approximating to *Georychus capensis* in size. (R.M.)

Hystrix sp. A complete ramus and an odd incisor.

Ungulata.

Phacochœrus æthiopicus, Pall. A right upper tusk and a portion of an upper tusk, showing scraping and chipping by human agency. A lower tusk.

Elephas africanus, Blumen. The proximal portion of a humerus, and part of a scapula.

Diceros, Gray. Two complete bones, a left humerus and a right tibia, of a rhinoceros, excavated by Mr. Franklin White, were presented by him to the Museum. (R.M. No. 546.) On comparing these with bones of the modern *D. bicornis*, I find they differ so materially as to warrant their recognition as belonging to a distinct species. This may be known, after the discoverer, as *Diceros whitei*, sp. nov.

Diceros whitei, sp. nov. The humerus of this species differs most remarkably from that of *D. bicornis* in the shape of its distal end. The olecranon fossa is very much narrower than in *D. bicornis*, being 29 mm. in diameter, as compared with 51 mm. for a specimen of the latter. Indeed, the whole bone, although evidently that of a fully adult individual, is smaller and much slighter in proportion to its length, which is 330 mm., from the trochlea to the head of the humerus, while *D. bicornis* measures 358 mm. The tibia, although not differing to the same extent as the humerus, is nevertheless slightly narrower in proportion, and a little shorter. This species is evidently a form of rhinoceros smaller and less heavily built than *D. bicornis* For this reason it is also distinct from *D. simus*, and from *D. simplicidens*, Scott,[1] which is likewise larger than *D. bicornis*. I hope shortly to publish figures showing fully the differences between the species.

Equus sp. Several molars probably belonging to a zebra.

Connochætes taurinus, Burch. The basal portion of a horn-core.

Strepsiceros strepsiceros, Pall. An imperfect horn-core.

Taurotragus oryx, Pall. Portion of a horn-core.

In addition to the above there are in the Rhodesia Museum a number of bones and teeth of various other antelopes, not identifiable with certainty.

AVES.

An incomplete pelvis of a small bird, an ulna, and several leg-bones.

AMPHIBIA.

The ischial portion of a frog's pelvis; also an astragalus and calcaneum.

VI.—IRON ORE SUPPLIES.

By BENNETT H. BROUGH, Assoc. R.S.M., F.G.S., F.I.C.

OF all the problems with which the practical geologist has to deal, none is of greater importance at the present time than the discovery of fresh sources of iron ore supply. Every inhabitant of the United Kingdom, of the United States, and of Germany requires annually about a quarter of a ton of the iron of which the world last year produced 60,000,000 tons, the result of the smelting of over 120,000,000 tons of ore. Year by year the production and consumption are increasing, and many of the deposits of the richer ores are showing signs of depletion. The question of ascertaining how the demand for the vast supplies of iron ore that will in the future be needed will be met calls, therefore, for very serious consideration, and a few statistical notes may be useful as a contribution to a discussion of the subject.

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[1] Third Rep. Natal Geol. Survey, 1907, p. 257. In employing the generic name *Opsiceros* for his species, Scott has overlooked a paper by Thomas in P.Z.S., 1901, p. 158, where it is shown that Gray's name *Diceros* antedates by twenty years *Opsiceros*, Gloger.

During the past half-century the development of the iron industry has been remarkable. In 1854 Mr. J. K. Blackwell showed that the world's production of pig iron did not exceed 6,000,000 tons, of which the United Kingdom produced 50 per cent., France and the United States each 12½ per cent., and Germany 6·6 per cent. In 1905 the world's production had attained the enormous total of 56,000,000 tons, of which the United States produced 42·7 per cent., Germany and Luxemburg 20 per cent., the United Kingdom 17·6 per cent., and France 5·5 per cent.

In Great Britain the principal iron-ore producing districts are Cleveland, in North Yorkshire, which in 1905 yielded 41 per cent. of the total output of the kingdom; Lincolnshire (14·8 per cent.), Northamptonshire (13·9 per cent.), and Leicestershire (4·7 per cent.), together yielding 33·4 per cent. of the total output; Cumberland (8·6 per cent.) and North Lancashire (2·7 per cent.), Staffordshire (6·1 per cent.), and Scotland (5·7 per cent.). The Cleveland iron ore occurs in a 10-foot bed in the Middle Lias, and contains about 30 per cent. of iron. It is worked by underground mining. In Lincolnshire, Northamptonshire, and Leicestershire the brown iron-ore beds form part of the Inferior Oolite, and contain about 33 per cent. of iron, the workings being mostly opencast. In Cumberland and North Lancashire the red hæmatite occurs in irregular masses in Carboniferous Limestone. It contains more than 50 per cent. of iron, and is worked by underground mining. The ironstone in Staffordshire and in Scotland is mostly obtained from mines that also produce coal.

Such, in brief, are the home deposits from which the British supply of 14,590,703 tons of iron ore, valued at £3,482,184, was obtained in 1905. Even that enormous output did not meet the consumption, and 7,344,786 tons were imported. Of that amount 78·5 per cent. was brought from Spain, 5·4 per cent. from Norway, 4·2 per cent. from Greece, 4·0 per cent. from Algeria, 2·6 per cent. from France, 2·6 per cent. from Sweden, 1·5 per cent. from Russia, and smaller quantities from Turkey, Germany, islands in the Pacific, Belgium, Newfoundland, India, Australia, Italy (Elba), Persia, Portugal, and other countries. In fact, the world is being ransacked for fresh iron-ore fields to supply ores for the British blast-furnaces. The port at which most of the ore was delivered was Middlesbrough (1,789,639 tons), then followed Glasgow with 1,042,179 tons, and then Cardiff with 875,462 tons.

While it is probable that the British iron-ore fields will be exhausted in a century or two, the outlook in other countries is similar. This is borne out by data relative to the available iron-ore supplies of the world which have been collected by Torneböhm for the Swedish Parliament, and, although largely conjectural, these figures are of great interest.

In the United States the iron-ore production in 1905 exceeded 42½ million tons, the highest output ever recorded, the ore containing more iron than the ores raised in Germany, in the United Kingdom, and in Spain combined. The bulk of the production was obtained in the Lake Superior region, where the five iron-ore belts or ranges (Marquette, Menominee, Gogebic, Vermilion, and Mesaba), beds of pre-Silurian age, have furnished since the beginning of regular mining over 300,000,000 tons of iron ore. The average percentage of iron in the ore is 55, the 60 per cent. ores produced ten years ago having been exhausted by wasteful mining methods. The amount of ore still available in the United States is estimated by Torneböhm at 1,100,000,000 tons.

In Germany and Luxemburg two-thirds of the iron ore raised (23½ million tons in 1905) is derived from the so-called minette beds of Jurassic brown iron ore. The seams yield on an average 36 per cent. of iron and 1·7 per cent. of phosphoric acid. Owing to the high percentage of phosphorus the ore was of little value until 1879, when the basic method of making steel was brought into practical use by Thomas and Gilchrist. The amount of ore still available in Germany is estimated at 2,200,000,000 tons.

In Spain the chief deposits are near Bilbao, the ores, which are of great purity, occurring in beds of Cretaceous age. Up to the present time the Bilbao district has yielded about 115,000,000 tons of ore, and for many years pessimistic estimates have been made of the quantity of ore remaining. Twenty years ago it was thought that by the year 1900 there would be no ore left. Nevertheless, in that year Bilbao exported 5,000,000 tons of ore, and Don Julio de Lazurtegui, the most competent authority, estimated that there were still over 57,000,000 tons left. The richest red hæmatite ores are, it is true, now exhausted, and brown hæmatites and spathic ores have taken their place, with the result that more attention has to be paid to calcination and to the washing of ores to enable them to satisfy market requirements. Torneböhm's estimate of the quantity of ore still available in Spain is 500,000,000 tons.

In Sweden deposits of magnetite of great purity occurring in gneiss supply material for the charcoal blast-furnaces, and ores rich in phosphorus are mined for export at Grängesberg, in Central Sweden, and within the Arctic Circle at Gellivare, Kirunavaara, and Luossavara, where there are ample supplies to meet the increased demand that is likely to arise. These deposits have been described in great detail by Dr. Stutzer in a paper submitted at the last meeting of the Iron and Steel Institute. The export of iron ore from Sweden in 1905 amounted to 3½ million tons. In Northern Norway important discoveries of similar iron-ore deposits have of late been made. The amount of ore still available in Sweden is estimated at 1,200,000,000 tons.

In France the most important deposits are the beds of Oolitic iron ore in the department of the Meurthe-et-Moselle; and in Russia the greater portion of the iron ore produced is obtained from the Ural region, where, on the western side, the ores are chiefly limonite and spathic ores of a stratified character, and, on the east, masses of magnetite associated with igneous rocks. The amount of ore available in France is estimated at 1,500,000,000 tons and in Russia at the same amount. The available resources of other countries are estimated by Torneböhm at 1,200,000,000 tons. Including 1,000,000,000 tons for Great Britain, he estimates the known available resources of the world at 10,000,000,000 tons.

The outlook for the British industry is not altogether a depressing one; for, whilst the rich ores of Bilbao and Elba are becoming scarce, there are still vast quantities of ore available in the north of Scandinavia, in the south of Spain, in Algeria, Canada, Cuba, Brazil, Venezuela, Chili, India, China (notably in the Shansi district), Australia, and South Africa. The high cost of carriage is, of course, an important factor; but the great economies which have and will be effected in transport will reduce this item. The future of the home demand is likely to be affected by the development of the basic open-hearth process of steel-making which enables phosphoric ores to be utilised. In the course of time such phosphoric ores will doubtless occupy a very prominent place in the manufacture of high-class steel. The development of magnetic concentration and of the briquetting of pulverulent ores for furnace use will render possible greater utilisation of poorer ores, while the development of the electric furnace will doubtless render it possible to utilise black sands and other titaniferous iron ores which, although met with in abundance, cannot at present be treated profitably in the blast-furnace. There need, therefore, be no immediate anxiety regarding the supply of the more impure iron ores, the application of which cannot fail rapidly to increase.

NOTICES OF MEMOIRS.

British Association for the Advancement of Science: Seventy-seventh Annual General Meeting held at Leicester, August 1st, 1907.

I.—Address to the Geological Section. By Professor J. W. Gregory, D.Sc., F.R.S., President of the Section.

(*Concluded from the September Number, p.* 418.)

IV. *Plutonists and Ore-formation.*—Belief in the earth's internal fires was most faithfully held amongst geologists by the Plutonists of the eighteenth century, and repudiated with equal thoroughness by the Neptunists, who refused to concede that volcanic action was due to deep-seated cosmic causes. Thus Jameson in 1807 stoutly maintained that volcanoes were superficial phenomena due to the combustion of beds of coal beneath fusible rocks, such as basalt, and that the explosions were due to the sudden expansion of sea-water into steam by contact with the burning coal. Volcanoes, according to this view, were correctly described as burning mountains, giving forth fire, flame, and smoke. The extreme Neptunist and Plutonist schools have long since been extinct, but the controversy is not quite closed. The battlefield is now practically restricted to economic geology, and the issue is the origin of some important ores.

Ore deposits present so many perplexing features that deep-seated igneous agencies were naturally invoked to explain them, and some of the most thorough-going champions of the igneous origin of ores make claims that remind us of the eighteenth-century Plutonists. The question is to some extent a matter of terms. Many of the ores which Vogt, for example, describes as of igneous origin he attributes, not to the direct consolidation of material from a molten state, but to eruptive after-actions due to the hot solutions and heated gases given off from cooling igneous rocks. Igneous rocks probably play a notable part in the genesis of most primary ore deposits; for the entrance of the hot ore-bearing solutions is rendered possible by the heat of the igneous intrusions, as Professor Kemp has well shown in his paper on "The Rôle of Igneous Rocks in the Formation of Metallic Veins." Professor Kemp limits the term 'igneous' to materials formed by the direct consolidation of molten material; and this decision seems to me to be most convenient. For example, the quartzite that is so often found beneath a bed of basalt is due to hot alkaline water from the lava cementing the loose grains of sand; the process is an eruptive after-action, but it would be unusual to call such a quartzite an igneous rock.

1. *Igneous Ores.*—That there are ores which are the products of direct igneous origin is now almost universally admitted. The mineral magnetite is a most valuable source of iron, and it is a constituent of most basic igneous rocks. If iron were a high-priced metal, such as tin or copper, of which ores containing one or three per cent. are profitably worked, then basalt would be an ore of igneous origin. Under present commercial conditions, however, basalt cannot be regarded as an iron ore. But if the magnetite in a basic rock had been segregated into clots or masses large enough and pure enough to pay for mining, then they would be iron ores formed by igneous action. There are cases of such segregations large enough to be mined. The most famous is Taberg, a mountain in Småland, near the southern end of Lake Wetter, in Sweden. It is a locality of historic interest; a view of it, as a mountain of iron, was published by Peter Ascanius[1] in the Philosophical Transactions in 1755, and Sefström discovered the element vanadium in its ore in 1830.

Taberg consists of an intrusive mass of rock composed of magnetite, olivine, labradorite, and pyroxene. Many theories of its formation have been advanced. The view generally adopted is that of Törnebohm, who described the rock as a variety of hyperite in which there has been a central segregation of magnetite to such an extent that some of it contains 31 per cent. of iron. Törnebohm claims to have traced a gradual passage from normal hyperite to a variety poor in felspar, then to one without felspar, and finally to a granular intergrowth of magnetite and olivine. This Taberg ore was mined and smelted for iron in the eighteenth century, when transport was more costly and commercial competition less keen than it is to-day. The ore has been worked at intervals as late as 1870; and as the hill is estimated to contain 100 million tons of ore above the level of the adjacent railway, it is not surprising that efforts are being again made to utilise the deposit, in spite of its low grade and high percentage of titanium. The Taberg hyperite has almost reached the line which divides magnetite-bearing rocks from useful iron ores. Its igneous origin, however, has not been universally accepted. The theory has been rejected by so eminent an authority as Posepny, according to whom the ore occurs in solid veins as well as in grains; and he holds that, like other Scandinavian iron ores, it was due to secondary deposition. During a visit to the mountain I failed to see any secondary veins, except of insignificant value. The microscopic sections of the ore show that it is a granular aggregate of olivine, generally with labradorite and pyroxene. Hence I have no hesitation in accepting the view of the Swedish geologists and regard Taberg as a magmatic segregation. Posepny[1] has in this case carried his Neptunist theory of the genesis of ores too far.

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[1] Vol. xlix, pp. 30–34, pl. ii.

At Routivaara, in Swedish Lapland, there is a still larger mass of magnetite, which is claimed, in accordance with the descriptions of Petersson and Sjögren, to be due to segregation from the magma of the surrounding gabbro. This mass of magnetite is of colossal size, but it is of no present economic value owing to its high percentage of titanium and its remote position.

An igneous origin is claimed by Professor Högbom for some small masses of titaniferous magnetite in the island of Alnö, opposite Sundsvall, on the eastern coast of Sweden. This case is of interest, as the surrounding rock is not basic: it is a nepheline syenite, containing only 2 per cent. of magnetite, which, however, has been concentrated in places, until some specimens (according to an analysis quoted by Professor Högbom) contain as much as 64 per cent. of magnetite, 9 per cent. of ferrous oxide, and 12 per cent. of titanic oxide.

The Alnö magnetites, again, are of no practical value, as they are too low in grade and too refractory in nature. I understand that about 500 tons of the material have been smelted, but with unprofitable results, and the rest of the material quarried has been left on the shore. We may therefore accept the iron-bearing masses of Alnö and Routivaara, as well as that at Taberg, as due to magmatic segregation, without having conceded much as to the igneous formation of ores. The process in this case has formed rocks, rich in titaniferous magnetite, from which iron could be obtained, but rocks which no ironmaster is at present willing to buy as iron ore. Whether a basic igneous rock is to be regarded as an iron ore, or as only useful for road metal, depends on cost of treatment. The definition of the term 'ore' is very elastic. Petrographers speak of the minute grains of magnetite or chromite in a rock as its ores; but that is a special use of the term 'ore.' Usually ore means a material which can be profitably worked as a source of metals under existing or practicable industrial conditions.[2] According to this definition, the Swedish deposits of titaniferous magnetite are at present doubtfully within the category of iron ores.

The famous iron mines of Middle Sweden at Dannemorra, Norrberg, Grängesberg, and Persberg occur under different geological conditions; they work lenticles or bands of ores in metamorphic rocks, of which some are altered sediments; and the view has therefore been held by de Launay and Vogt that the ores also are altered sediments.

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[1] F. Posepny, "The Genesis of Ore Deposits": Trans. Amer. Inst. Min. Eng., 1893, p. 323.

[2] The Oxford Dictionary adopts a still more restricted definition; according to it an ore is "a native mineral containing a precious or useful metal in such quantity and in such chemical combination as to make its extraction profitable."

That ores are formed by igneous segregation of sufficient size and purity to be of economic importance is a theory which rests on two chief cases—the nickel ores of Sudbury in Canada and the iron ores of Swedish Lapland.

2. *The Sudbury Nickel Ores.*—The nickel ores of Sudbury are the most important historically. They have been repeatedly claimed as of direct igneous origin by Bell (1891), von Foullon (1892), Vogt (1893), Barlow (1903), and by other geologists; and his view was advocated before the Association at the Johannesburg meeting by Professor Coleman. The theory was stoutly opposed by Posepny in 1893, and Professor Beck in 1901 described some of the brecciated ore, and showed that its metallic minerals are sharply separated from the barren rock. He held that such ore must have been formed, not only after the consolidation of the rock, but even after or during its subsequent metamorphism. The views of Posepny and Beck seem to have been established by additional microscopic study of the ores by C. W. Dickson (1903). He has shown that the sulphides are separated from the barren rock by sharp boundaries, and without any indication of a passage between them; that the fragments of ore in the rock have short corners, whereas, had they grown in a molten magma, the angles would have been rounded and the faces corroded. Most of the ore, moreover, occurs as a cement filling interspaces between broken fragments of barren rock and along planes of shearing. The Sudbury ores, therefore, appear to have been deposited from solution during or after the brecciation of the rocks in which they occur, and long after their first consolidation. If Dickson's facts be right, the Sudbury ores are necessarily aqueous and not igneous in origin.

3. *Scandinavian Iron Ores.*—The other important mining field of which the ores are claimed as of igneous origin is Swedish Lapland. Its ores are rich and the ore bodies colossal. One mine, Kirunavaara, yielded over one and a half million tons of ore in 1906, and according to a recent agreement with the Swedish Government the annual output of ore from that mine may be raised to three million tons by 1913.

The chief mining fields of Lapland, although situated to the north of the Arctic Circle, have long been known, for some of them contain veins of copper which were worked, for example, at Svappavaara in the seventeenth century. The iron ores, however, could not be used until a railway had been laid through the swamps of Lapland to carry the ores cheaply to the coast. In 1862 an ill-fated English company began a railway to the Gellivara mines, and thirty years later this was completed across Scandinavia, from the head of the Gulf of Bothnia at Lulea to an ice-free port at Narvik, on the Norwegian coast.

This railway, the most northern in the world, passes the two great mining fields of Gellivara and Kiruna. The mining field of Kiruna is the larger and at present of the greater geological interest, as its structure is simpler and its rocks less altered.

The ore body at Kiruna outcrops along the crest of a ridge two miles long, and it is continued beneath Lake Luossajarvi to the smaller but still immense ore body of Luossavaara. At Kiruna the ore rises to the height of 816 feet above the surface of the lake, and it varies in thickness from 30 to 500 feet, with an average thickness of about 230 feet. According to the report by Professor Walfrid Petersson,[1] submitted this year to the Swedish Parliament, Kirunavaara contains 200 million tons of ore above lake-level, and Luossavaara another 22½ million tons. The ore is high-grade. According to Lundbohm 60 per cent. of the trial pits showed a yield varying from 67 to 71 per cent. of iron, and 21 per cent. of them showed a yield of from 60 to 67 per cent. of iron. The average of nineteen analyses published in Professor Petersson's recent report gives the contents of iron as 64·15 per cent. Unlike the Taberg and Routivaara ores, the percentage of titanium is very low; thus in nineteen analyses given by Petersson the average of titanic acid is only ·23 per cent., and it varies in the specimens from ·04 to ·8 per cent.

The ore lies between two series of acid rocks, which have been very differently interpreted, but will no doubt be fully explained by the researches now in progress under the direction of Mr. Lundbohm. The rocks were first called halleflinta, as by Fredholm, and regarded as of sedimentary origin. They are now accepted as an igneous series, associated with some conglomerates, slates, and quartzites. The ore body itself is bounded on both sides by porphyrites, of which that on the lower or western side is more basic than that overlying the ore to the east. The basic western porphyrite is in contact with a soda-augite syenite of which the relations are still uncertain. Interbedded with the overlying eastern porphyrite are rocks that appear to be volcanic tuffs, and both in the tuffs and in the upper porphyrite are fragments of the Kiruna ore.

Three main theories of the genesis of the Kiruna ores have been proposed. Their sedimentary origin was urged on the ground that they occur regularly interstratified in a series of altered sediments, and that the ores, therefore, are also sedimentary. This view may be promptly dismissed, since the adjacent rocks are igneous.

The second theory has been advanced independently by Professor de Launay and Dr. Helge Bäckström: according to them the porphyrites above and below the iron ores are lava-flows, and the ore was a superficial formation deposited in an interval between the volcanic eruptions. According to de Launay the iron was raised to the surface as emanations of iron chloride and iron sulphide; the iron was deposited as oxide, and most of it subsequently reduced to magnetite during the metamorphism of the district.

The third theory—that the ores are of direct igneous origin—has been maintained by Löfstrand, Högbom, and Stutzer; according to them the ores are segregations of magnetite from the acid igneous rocks in which they occur. The segregation theory has been opposed, amongst others, by de Launay and Vogt. Thus, de Launay maintains that the segregation would have been impossible in such fluid lavas as the Kiruna porphyrites, and is improbable, since there is no transition between the ore and the barren rock.

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[1] *Bihang till Rikd. Prot.*, 1907, 1 Saml., 1 Afd., 84 Häft, No. 107, pp. 213, 217.

The ségregation theory has serious difficulties, and is faced by several obvious improbabilities. The ore occurs as a band nearly forty times as long as it is broad. It has the aspect, therefore, of a bed or a lode. The ore has not the granular, crystalline structure of an igneous rock like the hyperite of Taberg, but the aspect of a material deposited from solution or formed metasomatically. It is almost free from titanium, the undesirable constituent so abundant in the ores of Taberg and Routivaara.

The igneous theory cannot, however, be lightly dismissed, as it is supported by the high authority of Professor Högbom, and therefore demands careful consideration.

It has been advanced in two main forms, the one considering the ore to have been deposited at the time when the igneous rocks are consolidating, the other considering it was deposited at a later period. According to Professor Högbom, the ore was syngenetic, being a true magmatic segregation from a syenite. But, according to Dr. Stutzer (1906), the segregation was later than the consolidation of the syenite. He describes the lode as an intrusive banded dyke, of which the chief constituents are magnetite and apatite; and the injection of this dyke pneumatolytically affected the rocks beside it, producing an intermediate zone impregnated with ore, which he compares to contact deposits.[1]

In spite of the high authority of Professor Högbom, I am bound to confess that the Kiruna ores do not impress me as of igneous formation. Their bed-like form, microscopic structure, and poverty in titanium are features in which they differ from those admittedly due to direct magmatic segregation. The microscopic sections that I have examined suggest that both the magnetite and apatite were deposited from solution and later than the consolidation of the underlying porphyrite, which the ore in part replaces. An examination of the field evidence supports the conclusions of de Launay and Bäckström as to the ore being a bedded deposit overlying a lava-flow, but enlarged by secondary deposition.

V. *Future Supply of Iron Ores.*—This conclusion is perhaps economically disappointing. The possible existence of such vast segregations of iron in the acid igneous rocks has an important economic bearing. There is only too good reason to fear that the chief iron ores are comparatively limited in depth; for most of them have been formed by water containing oxygen and carbonic acid in solution, which has percolated downward from the surface. Ores thus formed are therefore restricted to the comparatively limited depths to which water can carry down these gases. On the theory, however, that these ores are primary segregations from deep-seated igneous rocks there need be no limit to their depth. They would rather tend to increase in size downward, while maintaining, or even improving, in the richness of their metallic contents. For these bodies may be regarded as fragments of the metallic barysphere which have broken away from it and revolve around it like satellites floating in the rocky crust. On this conception these ore bodies would be of as great interest to the student of the earth's structure as their existence would be reassuring to the ironmaster, haunted as he is by constant predictions of an iron famine at no distant date. It is no doubt true that many of the richest, most accessible, most cheaply mined, and most easily smelted iron ores have been exhausted. The black-band ironstone and the clay iron ores of the coalfields, which gave the British iron industry its early supremacy, now yield but a small proportion of the ores smelted in our furnaces. The Mesozoic beds of the English Midlands and of Yorkshire still supply large quantities of ore. Nevertheless the British iron industry is becoming increasingly dependent on foreign ores. So it would be pleasant to find that the Scandinavian iron mines are not subject to the usual limits in depth. I fear the typical iron deposits of Middle Sweden and of Gellivara will follow the general rule; but Kiruna may be an exception, and its ores may continue far downward along the surface of its sheet of porphyrite. The uncertainty in this case lies in the extent of the subsequent enrichment and enlargement of the bed; if most of the ore is due to secondary deposition, then it may be restricted to the comparatively shallow depths at which this process can act; and though that limit will be of no practical effect for a century or more to come, the ore deposit may be shallow as compared with gold-mines.

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[1] In a later paper, of which only a short abstract has been issued, Dr. Stutzer, however, explains that "the intrusion of the ore dyke was at relatively the same time as the formation of the syenite, and that the ores were formed by magmatic separations *in situ*, or as peregrinating magmatic separations (magmatic veins and bedded streams)." He adds that "pneumatolysis plays no inconsiderable rôle in the formation of these veins." Dr. Stutzer's position may be summarised as regarding the ores as collected by segregation, but deposited in their present position by eruptive after-actions.

The geological evidence may convince us that all the economically important iron ores are limited to shallower depths than lodes of gold, copper, and tin; but this conclusion shall not enrol me among the pessimists as to the future of the iron supply. Twenty years ago a paper on the gold supplies of the world was read to the Association at the request of the Section of Economics. About the time that the report was issued there were sixty-eight mining companies with a nominal capital of £73,000,000 at work upon the Rand. Nevertheless, the author, accepting the view that "the future of South African gold-mining depends upon quartz veins," concluded: "There is as yet no evidence that the yield will be sufficient in amount to materially influence the world's production. As regards India, the prospect is still less hopeful."

That quotation may be excused, as it is not only a warning of the danger of negative predictions, but of the unfortunate consequences that happen when geologists are unduly influenced in geological questions by the opinions of those who are not geologists. In economic geology, as in theoretical geology, we should have greater confidence in the value of geological evidence. Negative predictions are especially rash in regard to iron, it being the most abundant and widely distributed of all the metals. The geologist who knows the amount of iron in most basic rocks finds it difficult to realise the possibility of an iron famine; he can hardly picture to himself some future ironmaster complaining of "iron, iron everywhere, and not a ton to smelt." There are reserves of low-grade and refractory materials which the fastidious ironmaster cannot now use, since competition restricts him to ores of exceptional richness and purity. When the latter fail, an unlimited quantity could be made available by concentration processes. The vast quantities of iron ores suitable for present methods of smelting in Australia, Africa, and India show that the practical question is that of supplies to existing iron-working localities, and not of the universal failure of iron ores.

VI. *Mining Geology and Education.*—The genesis of ores and the extent of future ore supplies are intimately connected questions, and the recognition of this fact has led to the remarkable growth of interest in economic geology. This wider appreciation of the practical value of academic geology should, I venture to urge, be recognised among teachers by giving a more honoured place to economic geology.

It was inevitable that until the principles of geology had been firmly established, the detailed study of their application should have been postponed. Now, however, last century's work on academic geology enables the difficult problems connected with the genesis of metalliferous ores to be investigated with illuminating and practically useful results.

British interest in mining education has therefore been revived. Its history has been sadly fitful. Lyell,[1] in 1832, deplored the superiority of the Continent in this respect, as "the art of mining has long been taught in France, Germany, and Hungary in scientific institutions established for that purpose," whereas, he continues (quoting from the prospectus of a School of Mines in Cornwall, issued in 1825), "our miners have been left to themselves, almost without the assistance of scientific works in the English language, and without any 'School of Mines,' to blunder their own way into a certain degree of practical skill. The inconvenience of this want of system in a country where so much capital is expended, and often wasted, in mining adventures, has been well exposed by an eminent practical miner."

Though the chief British School of Mines made a late start, the brilliant originality of its professors soon carried it into the front rank; but in an evil day for the Mining School it was united with a Normal School for the Training of Teachers, now the Royal College of Science, and that school by its great success overwhelmed its older ally. Those interested in economic geology therefore welcome the recent decision to separate the technical from the educational and other courses, while leaving the Schools of Mines and Science sufficiently connected for successful co-operation. This policy should give such opportunities for the teaching of mining research that we may not always have to confess, as at present, that British contributions to mining geology do not rank as high as those made to other branches of our science.

Regrets are sometimes expressed, and perhaps still more often felt, at the tendency in scientific teaching to become more technical; but I, for one, do not fear evil from any such change. It is possible that the educational conflict of the future will be between academic science and technical science, on grounds in some respects analogous to those between classics and science during the last century. The advocates of the educational value of technical science are not inspired by mere impatience with the apparently useless, for they accept the principle that the essence of education is method, not matter. Therefore, they claim that the methods and principles of science can be better taught by subjects which are being used on a large scale in modern industries than by subjects of which the interest is still purely theoretical. Those who fear that academic science will be neglected if technical science be used in education may be encouraged by the brilliant revival of classical research since classics lost its educational monopoly. Academic science is even less likely to be neglected. It will always have its fascination for those intellectual hermits—shall I not say those saints of science?—who prefer to work for love of knowledge, free from the worrying intrusion of the mixed problems and fickle conditions of the industrial world; and the greater the progress of applied science the more urgent will be its demands for help from pure science, and, as a necessary consequence, the wider will be the appreciation and the more generous the endowment of scientific research.

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[1] C. Lyell, "Principles of Geology," vol. i, 2nd ed. (1832), p. 63.

Technical education must be as rigorous as that in academic education, and its connection with the fundamental principles must be as intimate. When so taught, economic problems provide at least as good a mental training as those branches of science which are purely theoretical. If the new Imperial College of Science and Technology carry on the mission for which the Geological Society was founded a century ago, if it inspire its students to have their delight in using past discoveries on the open surface of the earth, so that they may penetrate to what is within, then they will gain that sure knowledge of the formation and distribution of ores which is of ever-growing national importance.

II.—Some Desert Features.[1] By H. T. Ferrar, M.A., F.G.S.

CONTRAST between the deserts on either side of the Nile. The Western Desert, sometimes known as the Libyan Desert, presents all the features which one would expect to find in a region of deficient rainfall. There are broad featureless plains with no very definite drainage systems; there are long lines of sand-dunes stretching for tens of miles across the country; there are centripetal basins, and there are monadknocks or inselbergen, and an almost entire absence of vegetation.

The Eastern Desert, or the Etbai, on the other hand, displays an integrated drainage system; sand-dunes are conspicuous by their absence; vegetation is not scarce; and comparatively high mountains form a backbone to the country. These mountains are a true chain and form the water-parting between the Nile and the Red Sea. This water-parting is very much nearer the east coast, and, as in South Africa, so here we have the shorter and steeper eastward draining wadis

[1] By permission of the Director-General, Survey Department, Egypt.

beheading the longer westward drainages. The highest peaks usually consist of granite, which is sometimes foliated, and these high peaks, which rise majestically above the denuded schistose rocks, are not always on the actual watershed. Forms of rock and mountain sculptured by sandblast are not obvious, for the rain which occasionally falls destroys these and produces typical water-graded slopes.

The western desert surfaces consist of a thin veneer of waste, except where monadknocks or the escarpments of the oases display solid rock. This veneer of waste is protected, as in the Antarctic regions, by a layer of pebbles, which prevents the wind transporting the lighter material and prevents the rain-water from flowing in definite channels.

The eastern, or Etbai, desert shows bare hillsides, and the steep cliffs which form the wadi-walls are quite free from débris. The wadis or dry watercourses are at present being aggraded, and it is only in the wadi-beds that one finds the alluvium. This alluvium of boulders and rock-débris is usually from 5 to 50 feet in depth, and may be described as a torrential deposit. The only sorting of materials that is obvious in this region is that sorting due to water-action, where the volume of water and the slope of the ground are the determining factors.

Sorting of fine material from the coarse is not as common as one would expect. A high wind (Beaufort scale, force 8) will only move pebbles and grit less than 5 mm. in diameter, so that a succession of winds of unprecedented force would be necessary to produce 'pebble beds.' The pebbles of the gravels on the western plateau, near Wadi Natrum, are all rounded and water-worn, and form a heavy mantle over the land which prevents the wind from picking up the lighter material from below, which they protect. It is only those stones on the surface that are wind-etched or show the faceted form. These gravels were deposited during the pluvial period, immediately preceding the present arid one, and therefore it would seem that the only reliable test to prove that a deposit was a desert formation would be to find in it tetrahedral and wind-etched stones.

Photographs were exhibited to show some of the points referred to in this paper.

III.—The Origin of the Upper Keuper of Leicestershire. By T. O. Bosworth, B.A., F.G.S.

The Condition of the Rocks beneath the Keuper.—The Charnian igneous rocks beneath the Keuper are comparatively fresh right up to their surfaces, but where the marl has been denuded and the rocks are exposed to the present climate they are decomposed.

The Surface Features of the Rocks beneath the Keuper.—Smoothed, fretted, and curiously carved surfaces are seen at Mount Sorrel,[1] Croft, Sapcote, Groby, etc., and usually wherever the marl rests on igneous rocks. They are often pitted and sometimes highly polished (e.g. at Narborough). But where the rocks are cleaved or broken, as at Swithland and Bardon, the floor beneath the Keuper is rough and craggy.

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[1] Professor Watts, Geographical Journal, June, 1903.

The Nature of the Deposits.—Everywhere the beds dip in the direction of the surface slopes on which they lie, and the amount of dip depends upon the steepness of the slope. Catenary bedding is seen at Croft and Groby. Near the rocks the marl contains grit and stones, and there is generally a breccia at the base. The stones are of varied sizes, sometimes worn and sometimes very angular. They are in a remarkably fresh condition.

Both stones and grit are derived entirely from the particular rocks which the beds containing them surround. In these beds there is often a small amount of quartz sand, sometimes apparently wind-worn. It yields the same heavy minerals as the Upper Keuper Sandstone.

In many cases, e.g., around the South Leicestershire igneous rocks, this sand cannot be of local origin.

At Croft some of the Upper Keuper Sandstone consists of almost spherical grains, and appears to be a desert sand.

Near Leicester the sandstone is uniformly false-bedded from the south-west, and *Estheria* and fish-scales occur upon the false-bedding planes. Heavy mineral separations have been prepared from a large number of localities throughout the country. The mineral grains are generally very much worn. The most plentiful are garnet, magnetite, zircon, tourmaline, and rutile.

In the normal Keuper Marl bands showing false bedding, ripple-marks, and salt pseudomorphs are generally common.

But such evidence of subaqueous deposition as there is points rather to the existence of occasional streams and salt pools than to the deep waters of one great Keuper lake.

It is inferred that the Upper Keuper is a desert accumulation.

IV.—THE RELATION OF THE KEUPER MARLS TO THE PRE-CAMBRIAN ROCKS AT BARDON HILL. By W. KEAY, Assoc. M. Inst. C. E., and MARTIN GIMSON, Stud. Inst. C. E.

BARDON HILL is situated in the Charnwood Forest area, about ten miles north-west from Leicester. The hill rises to an elevation of 912 feet, and is higher than any of the land intervening between this point and the German Ocean.

The hill consists of Keuper marls resting unconformably upon Pre-Cambrian rocks, the latter protruding about 100 feet through the marls.

The object of this paper is—(1) To remark upon the unusual elevation of the Keuper marls. (2) To consider the probability of the entire submergence of the hill during the Triassic period.

1. *Elevation.*—Acting upon a statement of Professor Phillips that "the Triassic system offers the remarkable fact of never rising to elevations much above 800 feet," the authors by personal inspection, where possible, and by the aid of ordnance levels failed to discover any point on the Trias in England reaching a greater height than 800 feet except at Bardon Hill. Here, 'skerry' bands in the Keuper

marl may be seen at a height of 810 feet, and the marl may be traced in the fissures of the Cambrian rocks to a height of 880 feet. Hence the conclusion that the Keuper marls at Bardon reach an elevation at least as high and possibly higher than at any other point in the same strata in England.

2. *Submergence.*—The probability of Bardon Hill (912 feet), and therefore the whole Charnwood area, being entirely submerged during Triassic times presents itself as a problem.

The authors find at 810 feet two distinct 'skerry' bands resting upon, and overlain by, Keuper marl. In the Siberia Quarry the marl is found filling in two joints which rise nearly vertically a height of 80 feet. This 'filling' may be traced in the joints to a level of 880 feet, or 32 feet below the summit of the hill. There is no evidence suggesting the sudden termination of the marl at this level, but further tracing was prevented by vegetation. It is obvious that the marl must have been deposited from an elevation higher than 880 feet.

Further evidence in support of submergence is offered as follows:— The general dip of the marls in this district is from 1° to 3° S.E. Allowing an inclination of 1° only, or 90 feet per mile from a point at the junction with the Rhætics near Leicester, this would give (on the assumption that this inclination originally extended to Bardon) a covering of over 200 feet of marl above the present hill.

V.—On a hitherto unnoticed Section of the *Amaltheus spinatus* Zone and the Transition Bed in the Middle Lias at Billesdon Coplow, Leicestershire. By A. R. Horwood.[1]

THE author, after alluding to a section published by E. Wilson in the Geological Magazine, 1889, p. 296, of the Marlstone in the railway cutting at Tilton, Leicestershire, referred to a statement by that writer regarding it as the only exposure of the *Amaltheus spinatus* zone and Transition bed in the county.

Some recent researches, however, have resulted in the discovery of these beds in a little quarry on the road between Tilton village (some distance from the cutting quoted) and Billesdon Coplow, forming part of the escarpment called Life Hill, and about 700 feet O.D. There the very characteristic Gasteropod and Cephalopod zone of the Transition bed is well developed; and so uniform is this horizon in position and faunal contents that the author wished to see more stress laid on it than had previously been done, as indicating the uppermost beds of the Marlstone wherever found, being indeed a safe guide where other beds were wanting to denote this.

Another feature to be noted in the higher part of the Rock-bed, hitherto unnoticed or but little emphasised by previous writers on Liassic geology, was the occurrence of a very well-marked encrinital limestone band, varying from a foot to eighteen inches, though often less, of a very hard nature, less subject to the effects of weathering and decomposition than the Marlstone itself, which occurs some three or four feet lower in the section. This is to be found also on Tilton

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[1] Read before Section C (Geology), British Association, Leicester, 1907.

Hill, indicating there also the existence of higher beds than previously known. Its composition was much like some forest marbles, entirely differing from that of beds above or below, though traces of a similar structure occurred less regularly, but never as a definite layer or seam, in other parts of the section.

The horizon of Wilson's type-specimen of *Eodiadema granulata* had never been definitely ascertained, nor indeed that of the majority of the Gasteropods, etc., described by him as coming from Tilton, but found in the débris used in the construction of the East Norton embankment.

The Billesdon Coplow section solved this question, for there the same Echinoderm was found with a number of the same genera and species of Gasteropoda, Cephalopoda, etc. It had also been found by others, and there was an example from Desborough in the Invertebrate Department of the Leicester Museum under the writer's charge.

In conclusion the author wished to reiterate his remarks as to the importance for zonal purposes of this Gasteropod band of the Transition bed of the Middle Lias.

The character of the fauna stamped it decidedly as purely littoral or coastal, whilst that of the beds below, containing as they did chiefly Brachiopoda and deeper-water Lamellibranchs and Cephalopods, pointed to their being of a more pelagic nature.

It marked a change in the physical conditions which predominated at that period, and as such was rightly named a 'Transition bed,' for the Upper Lias fauna was itself only a modification of it, with some differences of lithological composition in the strata and of species in the fauna which characterised it.

Probably the inset of more littoral conditions took place between the formation of the thick encrinital seam mentioned above and that of the Transition bed. Certainly pelagic conditions, judging from the lithology and fauna of the beds below, seemed to come to a close about the time when this encrinital seam was deposited.

The thickness of the strata and the fauna of the two sections, the one at Tilton as described by Wilson and the other as discovered at Billesdon Coplow by the writer, were, with some slight differences, due to local causes, more or less identical.

VI.—NOTES ON THE ANCIENT VOLCANOES OF BASUTOLAND. By Rev. S. S. DORNAN.

BASUTOLAND is a high plateau between the Vaal and the Orange Rivers. It is the culminating point of the great plateau which fills the whole interior of the sub-continent. Upon this plateau, as a foundation, stand the great volcanic ranges, more than 11,000 feet high.

From the Caledon River to the edge of the great volcanic plateau is about fifteen miles. This plain is fairly level, and is interspersed with flat-topped mountains rising to 1,500 feet above the plain. These represent the original level of the country. The geology of the country is exceedingly simple. It is filled with the Stormberg series, lying nearly horizontal. The total thickness of these rocks amounts to 6,000 feet, of which the volcanic beds amount to 4,000 feet. The sandstones are loose and friable, and contain remains of plants, dinosaurs, and crocodiles.

The volcanic beds are the most striking rock features of the country, as they compose all the highest summits of the great ranges of mountains known as the Drakensberg and Malöte.

The vents from which the lavas and ash proceeded which have built up these great piles of rock can be roughly arranged in three or four parallel lines, corresponding to the present ranges of mountains. The first range consists of Machache, Thaba 'Telle, etc.; the second of Dikolobeng, Mokhele, etc.; the third of Mount Hamilton and Motai; and the last of the great summits of the Drakensberg, such as Mont aux Sources, Champagne Castle. Most of these mountains are 10,000 feet high and upwards. The rivers run in the synclines between these ranges of mountains, as a glance at the map shows.

The volcanic beds consist of lavas and ashes, with occasional silicious tuffs, intersected with intrusive sheets and dykes. Most of the lavas are amygdaloid; scoriaceous varieties also occur, but they are much less common. The beds are often full of pipe-like vesicles, filled with calcite, but often empty. These vesicles are inclined towards the vent. Basaltic lavas are common, and andesites also occur.

A short description of four of the most prominent peaks will serve as examples of the others.

(1) Thaba 'Telle. It is about 7,800 feet high, with steep—in some places precipitous—sides. It is composed of doleritic amygdaloid lavas, alternating with beds of ash. The plug is agglomerate, evidently the remains of the old throat. The lavas are full of steam holes. Thick deposits of purple ash also occur. Near the base of the mountain is a large intrusive sheet, surrounding what was formerly a subsidiary cone, but is now nothing more than a mere conical plug of agglomerate.

(2) Thaba Tsuen. This mountain is slightly lower than the preceding, but of beautiful conical shape. The height is 7,529 feet. It consists of two terraces and the agglomerate plug. The total thickness of lavas, ashes, and agglomerate is 1,600 feet. The plug proper rises from the second terrace, which slopes gently inwards, indicating the roots of the old cone. The plug is composed of coarse doleritic lava and agglomerate, and is about 500 feet high. It is a prominent landmark, and even more typically volcanic than many of the other peaks. The deposition of the lavas was not continuous, as there are thin intercalated beds of sandstone. The same feature occurs on all the other mountains examined.

(3) Thaba de Noha. This is a portion of the great Mokhele range. The plug and a portion of the old crater walls remain. The lavas at one point are glassy and steeply inclined, at another scoriaceous. There are also thick beds of ash. The characteristics of the lavas in this range are similar to the peaks previously mentioned.

(4) Thaba 'Ntso. This mountain is 7,560 feet high. It is part of a great range running perpendicular to the course of the Orange River. The composition of the lava beds is similar to Thaba de

Noha, the principal difference being that the beds of ash are thicker and better consolidated, evidently pointing to deposition in deeper water.

Many of the very highest peaks, such as Mont aux Sources, Motai, Mount Hamilton, are not described here, as the writer has never been able to visit them.

A short notice of the intrusive sheets and dykes is a necessary complement to the description of the lavas. These dykes, etc., are posterior to the volcanic beds which they traverse. None, so far as the writer knows, have the characteristic of a lava-flow.

They vary much in size, from a few inches thick and a few yards long up to 20 feet or more in thickness and several miles in length. Two remarkable examples of the latter kind occur in South Basutoland, near Mohales' Hoek. The dolerite is columnar, and as straight as if laid out artificially. Small displacement of the neighbouring strata is a conspicuous feature of these dykes.

The country owes its present configuration to two series of earth movements — one from west to east and the other from south to north, long afterwards. There is no evidence of denudation before the deposition of the lavas, and the writer is of opinion that the lavas were not all subaqueous.

VII.—LIFE-ZONES IN THE BRITISH CARBONIFEROUS ROCKS.[1]

THE part of the Report for 1906 which deals with the Carboniferous zones in Flintshire was founded on work done by Dr. Hind and Mr. Stobbs. Their conclusions were presented in a paper read before the Geological Society of London on April 4th, 1906. The Committee are not unanimously in agreement with some of the conclusions. On reference to the Abstr. Proc. Geol. Soc., No. 827 (1906), pp. 88–92, it will be seen that differences of opinion exist both as to the sequence and classification of the Carboniferous rocks of Flintshire.

In 1895, at the meeting of the Association at Ipswich, a paper was read before Section C by Messrs. Garwood and Marr in which they suggested "that a Committee be appointed to inquire into the possibility of dividing the Carboniferous rocks into zones, to call the attention of local observers to the desirability of collecting fossils with this view, and, if possible, to retain the services of eminent specialists to whom these fossils may be submitted."[2] As the result of that paper the present Committee was appointed at the same meeting.

Much has since been done, largely owing to the work of the Committee, and especially by the researches of Dr. A. Vaughan, whose well-known paper on the "Palæontological Sequence in the Carboniferous Limestone of the British Area" has in an eminently successful manner shown the possibility of the task for the consideration of which the Committee was initially appointed.

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[1] Report of the Committee, consisting of Mr. J. E. Marr (Chairman), Dr. Wheelton Hind (Secretary), Dr. F. A. Bather, Mr. G. C. Crick, Dr. A. H. Foord, Mr. H. Fox, Professor E. J. Garwood, Dr. G. J. Hinde, Professor P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. B. N. Peach, Mr. A. Strahan, Dr. A. Vaughan, and Dr. H. Woodward. Read before Section C (Geology), British Association, Leicester, 1907.

[2] Report British Association, 1895 (Ipswich), p. 696.

The Committee in submitting this final report desire to place on record their appreciation of the energy and enthusiasm of their secretary, Dr. Wheelton Hind.

Report on the work done.—Mr. H. Bolton, in an admirable paper, brought before the Geological Society the work he had done on the fauna of a marine horizon at the base of the Bristol Coalfield, a work towards which a portion of the grant was applied some two years ago. His paper will doubtless appear in the Society's Quarterly Journal, and it is unnecessary to say more here.

Mr. Tait, collector of the Geological Survey of Scotland, has been examining the Millstone Grit succession east of Lancaster this Summer; and Mr. Watson, of Owens College, has been working in the upper part of the valley of the Nidd. It has not been possible to examine their collections in time for this report.

The Secretary was fortunate enough to secure a fine collection of plants obtained in an abortive attempt to find coal at Thirshfield, near Grassington, in the valley of the Wharf. The exact place of the sinking is lat. 54° 3′, long. 2° 2′, and the shales are stated to be those which occur below a bed of Millstone Grit.

Mr. Kidston has kindly examined the specimens for him, and the following list is the result:—

Sphenopteris elegans, Bgt.
Calymmatotheca Stangeri, Stur.
Rhodia Moravica, Ett., sp.
Sphenopteris sp.
Calamites Ostraviensis, Stur.
Calamites sp.
Sphenophyllum tenerrimum, Ett., sp.
Lepidodendron sp.
Lepidostrobus sp.
Small Lycopodiaceous bract.
Rhabdocarpus (?) sp.

Mr. Kidston states, with regard to the horizon: "I have not the slightest doubt that the bed these specimens come from is on the horizon of the Upper Limestone group of the Carboniferous Limestone Series of Scotland." At any rate, we know that the Lower Limestone group of Scotland has a fauna which indicates the Upper *Dibunophyllum* zone.

VIII.—THE FAUNAL SUCCESSION IN THE CARBONIFEROUS LIMESTONE OF THE SOUTH-WEST OF ENGLAND.[1]

THE work has progressed steadily, but less rapidly than was anticipated owing to the necessity which has arisen of investigating the validity of certain genera and the correct application of specific names.

1.—*The Avonian Sequence in Gower.*

The zoning of the Avonian sequence of the Gower Peninsula, undertaken in conjunction with Mr. E. E. L. Dixon in the Summer of 1905, is now completed, and the results will be presented to the Geological Society early next session.

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[1] Report of the Committee, consisting of Professor J. W. Gregory (Chairman), Dr. A. Vaughan (Secretary), Dr. Wheelton Hind, and Professor W. W. Watts, appointed to enable Dr. A. Vaughan to continue his Researches thereon. (Drawn up by the Secretary.) Read before Section C (Geology), British Association, Leicester, 1907.

In this investigation the chief interest, from a zonal standpoint, centres in the occurrence of a higher faunal level than is known from any other point of the South-Western Province. The level here referred to is that of the Oystermouth Beds, of which the well-known Bishopston rotten-stones are the degraded representatives. The list of genera from these beds is practically identical with that from the Upper Tournaisian—a fact which may be taken to imply equivalence of environment. Important conclusions as to variation in time during the Viséan period have therefore been reached by comparing the several species of each genus at the Oystermouth level (uppermost Viséan) and those of the same genus in the Upper *Zaphrentis*-zone (Upper Tournaisian). The comparison of these two levels determines those characters of each genus which are indicative of old age; whereas the comparison of the Brachiopods (or of the Corals) at one and the same level determines those characters which are affected by convergence.

Mr. Dixon's careful study of the conditions of deposition which are implied by the several lithic types increases very greatly the value of the zonal investigation by preventing the error of mistaking a change of fauna with change of conditions for a true zonal sequence dependent upon evolution.

2.—*The Carboniferous Sequence from Rush to Skerries, Co. Dublin.*

(*In conjunction with* Dr. C. A. Matley.)

The stratigraphical relations have been admirably worked out by Dr. Matley, in spite of a quite remarkable intricacy of tectonic detail.

From a zonal point of view the main subject of inquiry is the true relative position of four distinct series whose sequence with one another is broken either by faults or gaps. The problem has been solved by a broad comparison of the coral faunas and their sequence in the South-Western Province. The relative position of the several portions has thus been established, and it has consequently become possible to draw up a detailed faunal sequence for the whole section. This sequence starts in the Upper Tournaisian, and extends beyond uppermost Avonian, being, however, notably incomplete in its middle portion.

The highest beds, which still exhibit an abundant Avonian fauna (the Upper *Cyathaxonia* beds), include a maximum of *Posidonomya Becheri*, and at the same time contain several strikingly specialised forms of Corals and Brachiopods which also occur in the Lower Limestones of Scotland and in the uppermost Limestones of the western Midlands and Settle. Much light has thus been thrown upon the true correlation of the uppermost Avonian rocks in widely distant areas.

These results will be published at an early date.

3.—*Palæontological Work.*

The palæontological work arising out of these two papers has been very considerable, and is as yet incomplete.

Minute study of the material collected, and comparison with that already gathered from the South-Western Province and other British localities, has shown the necessity of a re-investigation of the value of the characters upon which certain genera have been founded—e.g., the presence of a septum in Orthotetids, the existence of original fringes in Athyrids, the septation of Zaphrentids, etc.

I am also engaged upon the study of the types of Carboniferous Brachiopods preserved in the British Museum, and in this task Mr. S. S. Buckman has very kindly placed his long experience at my service.

I have also to acknowledge the great help which I have received from Mr. R. G. Carruthers in studying the Zaphrentids, and from many fellow-geologists who have sent me material for examination, and thus allowed me to keep in touch with the progress of research outside the areas in which I have myself worked.

So much remains to be done that I feel justified in asking for the continuance of this Committee for yet another year.

IX.—NOTE ON A NEW SECTION IN THE GLACIAL GRAVELS OF HOLDERNESS. By T. SHEPPARD, F.G.S., and J. W. STATHER, F.G.S.[1]

THE North-Eastern Railway Company has recently been making some extensive excavations in a hill situated between the well-known Kelsey Hill and Burstwich Gravel-pits in Central Holderness. At the present time the section exposed is probably the finest of its kind in the country. The cutting is made through the heart of the hill, and the exposed section is 1,300 feet long and 45 feet high in the centre, from which the section gradually slopes. The sides of the hill are flanked by Boulder-clay, and irregular masses also occur at intervals in the gravel. There are two types of Boulder-clay visible, the upper or Hessle Clay, containing a preponderance of Cheviot rocks, and the purple or middle Boulder-clay with its Carboniferous limestones and basalts. The gravels are somewhat similar to those described by Mr. Clement Reid at Kelsey Hill as Interglacial, but the present authors consider them to be merely part of the terminal moraine of the North Sea ice-sheet. In addition to the far-travelled boulders, a lengthy list of marine shells, mostly of an Arctic type, has been compiled, and the species *Cyrena* (*Corbicula*) *fluminalis*, a fresh-water form, also abounds. An interesting collection of mammalian remains has been secured, and includes bones of *Elephas primigenius*, Rhinoceros, Walrus, Red Deer, *Bison priscus*, Horse, and *Bos*. Some of these bear evidence of having been gnawed by the Hyæna. It is thought that the shells and mammalian remains have been caught up by the moving ice mass, and in this way incorporated in the moraine.

X.—ON A MARINE PEAT FROM THE UNION DOCK, LIVERPOOL.[1] By J. LOMAS, A.R.C.S., F.G.S.

DURING excavations in the Union Dock on the Mersey Docks and Harbour Board Estate in the South End of Liverpool a very remarkable peat band was discovered. Reckoning downwards from a datum-line 3 feet above Old Dock Sill a section showed:—

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[1] Read before Section C (Geology), British Association, Leicester, 1907.

	ft.	ins.
Sand with black carbonaceous bands	4	0
Peat	0	6
Blue clay with rootlets	4	0
Sand with thin bands of peat	2	10
Boulder-clay	3	2
Bunter pebble beds	8	0+

The upper peat was entirely composed of marine plants, laminaria predominating. On the fronds were numerous encrusting organisms, such as polyzoa, hydrozoa, the fry of young molluscs, etc.

The lower peat, while consisting mainly of marine plants, contained a few drifted pieces of oak and other land plants.

The sands accompanying the peat resemble those of the Mersey Bar, and besides the quartz which makes up the bulk of the deposit, contain zircon, garnet, tourmaline, dolomite, kyanite, rutile, staurolite, orthoclase, felspar, biotite and muscovite, shell fragments, foraminifera, sponge spicules, and polyzoa.

The deposit was probably accumulated in a sheltered bay in the old estuary of the Mersey.

The chief interest lies in the fact that peat may be formed from marine as well as from land plants.

XI.—THE DISTRIBUTION OF RADIUM IN THE ROCKS OF THE SIMPLON TUNNEL.[1] By Professor J. Joly, Sc.D., F.R.S.

THE principal classes of material which enter into the composition of the massif of the Simplon are: (*a*) The Jura-Trias sediments, lithologically often much alike and much interfolded; (*b*) the Palæozoic crystalline schists; and (*c*) the gneiss of Monte Leone and the Antigorio gneiss, both stated to be of Archæan age. These rocks throughout contain radium, and for the most part in quantities much above what hitherto has been ascribed to sedimentary or igneous rocks.

Some thirty-six typical samples, taken from various points in the tunnel, have been examined. The poorest in radium are certain anhydrite rocks. Certain amphibolite schists go very high. The Antigorio gneiss rises from $10{\cdot}5 \times 10^{-12}$ and $8{\cdot}0 \times 10^{-12}$ grams radium per gram of rock at the Italian entrance to $23{\cdot}7 \times 10^{-12}$ at 4,000 metres inwards. Some of the Archæan gneisses yielded very high results.

Such quantities of radium if generally distributed throughout the rocks of the massif would be sufficient to disturb any forecast of the temperature which under normal conditions would be encountered at the level of the tunnel. It is suggested that the radium was, in fact, the source of the discrepancy between the predicted and the observed rock temperatures.

As it is improbable that these results are unique and apply only to this particular sedimentary accumulation and locality, they appear to point to hitherto unsuspected quantities of radium (and its parent elements) in the immediate surface materials of the earth. It seems impossible to avoid the conclusion that these elements were precipitated along with the sediments entering into the composition of the massif. The question then arises whether the accumulation of such quantities of radio-active elements may not enter as a factor in the events attending mountain-building. It can be shown that an area of sedimentation whereon has been accumulated some 10,000 metres of sediments, having a richness in radium comparable with the Simplon rocks, must necessarily become an area of greatly lessened crust-rigidity, and would hence become the probable site of crust-flexure under tangential compressive stress.

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[1] Read before Section C (Geology), British Association, Leicester, 1907.

Further investigation will be required before such views can be generalised and the importance of radium as a source of instability of the earth's crust be determined. Apart from any speculations as to the influence of radium as the cause of an energetic substratum, the shifting of radium and its parent elements by denudation must be regarded as a convection of thermal energy, and this convection, if the quantities involved are sufficient, must, under the conditions referred to above and the unceasing action of denudation, become rhythmic in operation, and at the same time must result in shifting the areas of high temperature and crust-weakness from age to age as the site of sedimentary accumulation changes.

XII.—THE FELSITIC AGGLOMERATE OF THE CHARNWOOD FOREST.[1] By F. W. BENNETT, M.D., B.Sc.

THE rocks lying between the Beacon Series and the Blackbrook formation comprise a greater variety than has been hitherto recognised. Three main beds can be distinguished, which may be called the coarse, white, and pink grits. The pink grit, which is the uppermost bed, is the one to which almost exclusively the name of 'Felsitic Agglomerate' has been hitherto given.

Careful examination of the rocks in the Buck Hills has now conclusively proved that they belong to the Felsitic Series.

The rocks in the north-west of the Forest have always given rise to much difficulty. It is possible to trace the Felsitic Agglomerate as a distinct series of rocks in Timberwood Hill. The ground in this part of the Forest has been extremely faulted, and a good example of this occurs in Collier Hill.

To the north of the monastery, rocks have now been traced which evidently lie on the horizon of the Felsitic Series. They differ in some ways from the ordinary agglomerate type, especially as regards their texture, which becomes highly crystalline. It is found that these Felsitic rocks have been intruded into by igneous flows, both near the Cademan area and also in Bardon Hill; and it is probably due to this cause that the texture of the rock has been so much altered.

The position of these beds in relation to the Bomb rocks makes it probable that they correspond to the Felsitic Series, and this correlation is confirmed by comparison of some of the more recently discovered types with those of the ordinary Felsitic Agglomerate rocks.

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[1] Read before Section C (Geology), British Association, Leicester, 1907.

XIII.—ON THE OCCURRENCE OF BOULDERS OF STRONTIA IN THE UPPER TRIASSIC MARLS OF ABBOTS LEIGH, NEAR BRISTOL.[1] By HERBERT BOLTON, F.R.S.E., F.G.S.

A CONSIDERABLE area of the park attached to Leigh Court, near Bristol, has been found to be underlaid by a remarkable deposit of huge boulders of strontia embedded in Triassic marls. The boulders in various places appear above the surface. The soil varies in depth from a few inches to 4 feet, and rests upon the irregular surface of the marl-beds containing strontia. The boulders of strontia are found of all sizes, from a pea up to masses estimated at 100 tons in weight. In one instance the breaking-up of a single boulder of strontia occupied six men for five weeks. Six hundred tons of the mineral were found in one pit, 15 yards long by 21 yards wide.

The upper surface of the boulders is usually deeply grooved, the grooves running approximately north and south. The boulders readily split into slabs along lines coinciding with the grooves. The deposit up to the present has not exceeded a greater depth than 11 feet. The yield of strontia is about 2,000 tons per acre.

XIV.—INVESTIGATION OF THE FOSSILIFEROUS DRIFT DEPOSITS AT KIRMINGTON, LINCOLNSHIRE, AND AT VARIOUS LOCALITIES IN THE EAST RIDING OF YORKSHIRE.[2] By J. W. STATHER, F.G.S.

AS was intimated in our report for 1905, the work during the past year has been directed to the investigation of the deposit at Bielsbeck, or Bealsbeck, in the Vale of York, which was examined between seventy and eighty years ago by the Rev. W. V. Harcourt, and yielded the remains of numerous extinct mammals. The object of our investigation was mainly to ascertain if any further evidence could be obtained to show the relation of this fossiliferous deposit to the glacial drifts.

The work, which was carried out under the superintendence of Professor P. F. Kendall, Messrs. G. W. B. Macturk, Thomas Sheppard, and the Secretary, confirmed the statements of the previous observers: (1) that the deposits yielding the bones rested immediately on the Keuper Marl; (2) that they have been accumulated in a boggy hollow on an old land surface; and (3) that at this particular locality there is no material that can be assigned to the direct agency of ice. It therefore still remains a debatable question whether the bone-bearing material was accumulated before, during, or since the Glacial period; and it would appear that the elucidation of this matter will depend upon the investigation of a wide area to determine what was the condition of the Vale of York during that period.

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[1] Read before Section C (Geology), British Association, Leicester, 1907.

[2] Report of the Committee, consisting of Mr. G. W. Lamplugh (Chairman), Mr. J. W. Stather (Secretary), Dr. Tempest Anderson, Professor J. W. Carr, Rev. W. Lower Carter, Dr. A. R. Dwerryhouse, Mr. F. W. Harmer, Mr. J. H. Howarth, Rev. W. Johnson, Professor P. F. Kendall, and Messrs. G. W. B. Macturk, E. T. Newton, H. M. Platnauer, Clement Reid, and Thomas Sheppard. (Drawn up by the Secretary.) Read before Section C (Geology), British Association, Leicester, 1907.

The absence of glacial deposits in this part of the country may, on the one hand, imply that the area was never glaciated; or, on the other hand, it may mean that glacial deposits once existing have been entirely removed. If the former be the case, the bone-bearing deposits might belong to the pre-Glacial or to any younger stage; while if the latter supposition should find confirmation the deposit must be later than the glaciation.

The site of the original excavation is still visible, the hollow from which the 'marl' was dug being now a reedy pond. The new sections consisted of four pits sunk in the vicinity of the pond.

These pits were roughly from two to four yards square, and were carried down until the Keuper Marl was reached or the work was stopped by the influx of water. They were supplemented by several boreholes put down to determine the extent of the deposit.

The sections revealed in the pits were as follows:—

Section 1.

	ft.	ins.
Surface soil	0	9
Sand, with small pieces of angular chalk and flint	2	0
Gravel of rounded chalk and subangular flint	1	6
Silty blue-black marl or loam, the upper surface very irregular and penetrated by 'pipes' and pockets of gravel from the bed above	3	9
Marl as above, with specks of vivianite	1	0
Black marl	6	0
Lighter-coloured marl, passing downwards into gravel (chiefly flints)	7	6
Total depth reached ...	22	6

Section 2.

Surface soil	0	9
Sand	1	9
Gravel	2	0
Dark silty marl, with gravel	2	6
Dark marl	4	0
Lighter marl	4	0
	15	0

Section 3.

Soil	1	0
Sand	2	0
Gravel	3	0
Grey marl, passing downwards into black	7	6
Coarse gravel	0	6
Solid Keuper Marl, blue	3	0
Solid Keuper Marl, red	1	0
	18	0

Section 4.

Soil	0	9
Sand	3	6
Gravel	1	6
Keuper Marl, its surface dipping at 1 in 3 towards the old marl-pit	1	3
	7	0

From the black muds or marls which occurred below the superficial gravels in these pits the following fossils were obtained :—

Bones.—For the following determination we are indebted to Dr. C. W. Andrews, F.R.S., of the British Museum (Natural History), South Kensington.

MAMMALIAN REMAINS.

Cervus sp.
Bos sp. (two vertebræ).
Bos sp. (smaller than *longifrons* or *primigenius*).
Bos primigenius.
Elephas (rib and left scapula).

The bones were not confined to any particular layer, but were distributed sporadically throughout the mass of the marl. The overlying gravels, however, contained neither bones nor other vestige of contemporaneous life, possibly because of their removal by percolating water.

Shells.—The molluscan remains distributed through the marl belong to existing land and fresh-water species, many of which are still living in the neighbourhood. They are all species of wide range, and afford no definite indications as to climate. These species, kindly determined for the Committee by Mr. J. W. Taylor, of Leeds, are as follows :—

MOLLUSCA.

Limnæa peregra.
,, *palustris.*
,, *truncatula.*
Succinea putris.
,, *elegans.*
Hyalinia nitidula.
Zonites fulvus.
Helix nemoralis.
,, *hispida*, var. *concinna.*
,, *pygmæa.*
,, *pulchella.*
Vertigo antivertigo.
,, *pygmæa.*
Cochlicopa lubrica.
Carychium minimum.
Pisidium amnicum.
,, *pusillum.*
,, *nitidum.*
,, *milium.*
,, *obtusale.*
Bythinia tentaculata.
Valvata cristata.
Planorbis spirorbis.
,, *contortus.*
,, *glaber.*
,, *marginatus.*

Plants.—The material also contained plant remains, but was difficult to wash and sift. Some small seeds were, however, picked out by Mr. Stainforth, and were submitted to Mr. Clement Reid, F.R.S., for determination, who recognised the following :—

SEEDS OF PLANTS.

Ranunculus sceleratus.
,, *repens.*
Viola sp.
Œnanthe aquatica, Poir.
Rumex.
Sparganium erectum?
Carex.
Alisma plantago.

With regard to the above list Mr. Reid remarks: "If these were all that were found at Bielsbeck, they are an exceptionally poor set, which shows nothing as to climatic conditions." "There are only one or two seeds of meadow plants among them, and no dry-soil plants."

Insects.—Besides the above the deposit contains the remains of beetles, but much of the material has not yet been specifically determined. The following may be mentioned :—

COLEOPTERA.

Donacia (sp. ?) (an almost complete specimen).
Hister (sp. ?) (elytron).

Further Notes on the Deposits.—The Bielsbeck bone-bearing deposits apparently occupy a depression or hollow in the Keuper Marl of undetermined width, and it appears as though this hollow is isolated and inclosed by the marl, though it is just possible that it may represent a portion of a filled-in valley or trench, the direction of which has not been traced.

Scattered through the marl at various depths were angular or slightly rounded black flints in large numbers, and these in some cases formed a definite layer. Along with the flints were occasional pebbles of quartz and of sandstone (probably Carboniferous). None of these pebbles showed striæ or other indication of glacial action.

The overlying gravel was mainly composed of flint and chalk from the neighbouring Wolds, along with scattered fragments of quartz, sandstone, etc. (like those found in the underlying marl), and *Gryphæa* and other fossils from the Lias. This gravel is the feather-edge of a wide fan which can be traced up to the mouth of a valley that drains from the Wolds at Market Weighton. In the thicker parts of this gravel, towards the mouth of the valley, other pebbles besides the above have been detected, including the well-known porphyrite which is characteristic of the upper part of the East Yorkshire drifts. The wide extent and depth of this gravel suggests that it has been spread out by floods from the melting ice, when the ice-margin abutted upon the eastern slopes of the Wolds. The present valley appears to be too short to supply a stream powerful enough to spread a sheet of gravel of these dimensions.

The thanks of the Committee are due to W. H. Fox, Esq., for permission to excavate; to the tenant, Mr. Howes; to Mr. W. H. Crofts; and to the contractor, Mr. Thomas Moate.

The Committee had contemplated work on another site in East Yorkshire, but have found difficulty in obtaining the requisite permission. Pending a final settlement of this matter, they ask for reappointment, with power to use the unexpended balance of their grant.

REVIEWS.

I.—OFFICIAL CONTRIBUTIONS TO THE PALÆONTOLOGY OF SOUTH AUSTRALIA. By R. ETHERIDGE (Jun.[1]). RECORDS OF NORTHERN TERRITORY BORING OPERATIONS. By H. Y. L. BROWN, Government Geologist. Folio; pp. 22, with 12 plates. (Adelaide, 1907.)

IN continuation of the Northern Territory Report, No. 17 deals with Permo-Carboniferous fossils of Cape Dombey, etc. The only specimens capable of specific determination belong to *Aulosteges*, viz. *A. Baracoodensis* (pl. i, figs. 1–5). This shows internal structure.

No. 18. Carboniferous fossils from Fossil Head, etc. A considerable series, including Brachiopoda, Pelecypoda, Gasteropoda, and Cephalopoda, are described and figured, namely:—

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[1] [Mr. Etheridge being deceased, Mr. Robert Etheridge ceases to be 'Junior.'—EDIT. G.M.]

BRACHIOPODA.

Spirifera Musakheylensis, Davidson.
Orthotetes Perfidiabadensis, Eth., sp. nov.
Strophalosia, sp. indet., cf. *S. Jukesii*, Eth.
Chonetes, sp. indet., cf. *C. Prattii*, Davids.

LAMELLIBRANCHIATA.

Aviculopecten (?) *Hardmani*, Eth. fil.
A. tenuicollis, Dana.
Pteronites ?
Merismopteria ?
Nuculana Basedowi, Eth., sp. nov.
N. Waterhousei, Eth. fil. (var.).
Oriocrassatella Stokesi, Eth., gen. et sp. nov.

GASTEROPODA.

Ptychomphalina humilis, de Kon., sp.
Bellerophon costatus, J. de C. Sby.
Bellerophon, var. *pennatus*, Eth., var. nov.
Bucania Emerii, Eth., sp. nov.

CEPHALOPODA.

Pleuronautilus (?) *multicostatus*, Eth., sp. nov.

No. 19. Fossils from the Port Keats bore, thirty miles north of Fossil Head. After passing through what may be Mesozoic beds, fossils of Permo-Carboniferous or Carboniferous age were obtained, including two Foraminifera, several species of Polyzoa, a coral (*Dybowskiella*), a Brachiopod (*Chonetes*), and leaves of *Glossopteris*; the more important are described and figured. They comprise:—

FORAMINIFERA.

Nubecularia Stephensi, Howchin.
Cornuspira involvens, Reuss (?).

ACTINOZOA.

Dybowskiella Geei, Eth., sp. nov.

POLYZOA.

Ramipora sp.
Rhombopora Hindei, Eth., sp. nov.
Streblotrypa Browni, Eth., sp. nov.

Nos. 20, 21, and 22 deal with Cretaceous fossils from three localities, two of which are near Port Darwin. Plates are devoted to *Ancyloceras*, etc., though the genus is queried, and to *Ammonites Rhotomagensis*, which Mr. Etheridge says more resembles the British Chalk form than it does that from the Ootatoor group of Southern India. The species previously described from the Point Charles deposit (No. 20) and also obtained by Mr. H. Y. L. Brown and his party comprise:—*Aucella incurva*, Eth. fil.; *Nucula sejugata*, Eth. fil.; *Desmoceras carolensis*, Eth. fil.; *Histrichoceras antipodeus*, Eth. fil.; *Scaphites cruciformis*, Eth. fil.; *Crioceras* (?) sp.; *Hamites* (?) sp.; *Ancyloceras* (?); *Belemnites* sp.

From No. 21, Shoal Bay, several of the same species of Cretaceous fossils were obtained, and in addition a specimen referred to the genus *Baculites* under the name of *Baculites Williamsoni*, Eth., sp. nov.

At locality No. 22, Maclear Creek, Cape Gambier, Melville Island, the common form *Inoceramus Etheridgei* was obtained, and an Ammonite (like our British form) named *Metacanthoplites Rhotomagensis*, Brongn.

Plates iii and iv. Typical blocks of groups of *Aviculopecten Hardmani* have been prepared by process from excellent photographs by H. Barnes, jun. The other ten plates are drawn by Frank R. Leggatt, and are very good so far as the specimens (many of which are very fragmentary) permit.

We are greatly indebted to Mr. Robert Etheridge in this, as in his many earlier memoirs, in which he has so largely contributed to our knowledge of the palæontology of the older rocks on the Australian Continent.

II.—GEOLOGICAL SURVEY OF SCOTLAND.

THE GEOLOGY OF ISLAY. By S. B. WILKINSON[1]; with notes by J. J. H. TEALL, F.R.S., and B. N. PEACH, F.R.S. Memoirs of the Geological Survey. pp. vii, 82, with 6 figures and 8 plates. 1907. Price 2*s.* 6*d.*

THE island of Islay is of the first importance in the interpretation of the geology of a large part of the Highlands of Scotland. The Lewisian and Torridonian rocks of the west coast there come into juxtaposition with the Central Highland schists. The one series extends northwards to Cape Wrath, the other stretches through Argyllshire and Perthshire to the shores of the Moray Firth. In Islay they meet, as they do in no other part of Scotland. The geology is complicated by the presence of another group of rocks which may be Cambrian. Only the Moine Schists and the grits and slates of the southern border of the Highlands (with the Loch Tay limestone) are wanting to make Islay a complete epitome of Highland geology. For these reasons we turn to this memoir with much curiosity to know the results of the most recent work in this quarter.

The structure of the island is sufficiently simple in its broad outlines. On the west there are Lewisian and Torridonian rocks, both in their typical development. The Lewisian is penetrated by many sills and dykes of epidiorite. Both sets of rocks have been locally much crushed. On the east side of Islay we have the Central Highland schists (Blair Atholl or Islay limestone, black schist, and Ardrishaig phyllites) with a group of quartzites, dolomitic shales, etc. Between those two formations there is a conglomerate, the Portaskaig conglomerate. There seems to be no doubt that the quartzite group rests upon the limestone, and that there is a slight unconformability at the junction.

Nearly through the middle of the island there runs a great north and south thrust-plane, a continuation of the series of post-Cambrian thrusts of the north-west of Scotland. To the west of it lie the Lewisian and Torridonian, to the east the Central Highland schists and quartzite. The break is absolute. The two sides of the island are entirely unlike; only the epidiorite sills are found on both sides of the thrust (if we except the Tertiary dykes and later rocks). This is a great disappointment, for it means that Islay gives no direct clue to the time-relationships of the two sets of rocks which form its opposite sides. The interest centres, accordingly, in the north-east corner of the island, where the quartzite and Central Highland schists are folded together in intricate fashion.

The quartzite group of Islay, resting unconformably on the Central Highland schists, possesses many features which give it a strong resemblance to the Cambrian rocks of Sutherland. The lithological characters and apparent succession are the same; there are sandy dolomitic shales, with worm-castings, which are described as 'fucoid beds.' In the quartzite there are several kinds of worm-burrows which are strictly comparable with those found in the Assynt quartzite. Dr. Peach describes these as "exactly similar to those which characterise three of the zones into which the upper part of the Cambrian quartzite or 'pipe rock' of the North-West Highlands has been divided by the Geological Survey" (p. 44), and reading between the lines one can see how strongly he has been impressed with the evidence. Yet these rocks are nowhere stated, in map or memoir, to be Cambrian. Most unfortunately the final proof is lacking; careful search in the dark shales of the north of Islay has failed to yield any trace of the fauna of the *Olenellus* zone where its presence might confidently have been predicted.

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[1] [We have every reason to believe that S. B. Wilkinson, above-named, is the same as B. S. N. Wilkinson, part author of memoir on the Geology of West Gower, noticed in the August Number of the GEOL. MAG. Bibliographers may, however, be puzzled.—EDIT.]

The reasons for the great caution with which this subject has been handled are not explicitly stated in the memoir; we are left to gather them for ourselves. If the Islay quartzite be Cambrian this carries with it important results in Highland geology, as this quartzite extends into Jura and Scaba. By means of its boulder beds it can be identified with certain quartzites in Argyllshire and with the quartzite of Banffshire. The Cambrian colours would sweep into the mainland, reaching right across Scotland. The Central Highland schists would be a sub-Cambrian formation, not always certainly separated by an unconformability from the quartzite, and much of the folding and metamorphism of these rocks must be of post-Cambrian date. This gives us pause, and we can sympathise with the authors in hesitating to found generalizations of this order on evidence which is not in itself incontrovertible.

The memoir, for the area covered, is a brief one, not cumbered with topographical or petrographical details. It is illustrated with some fine photographic views and contains a bibliography of Islay geology. The editorial work has been well done, and the contributions by the different authors are skilfully joined, so that the chapters read smoothly throughout. The book gives us the impression of minutely careful work, carried out in a spirit of judicial impartiality and described with clearness and reserve. The unsettled problems of the geology of Islay lose none of their fascination from the treatment they receive in the memoir, and Islay remains one of the most beautiful and perplexing of the islands of Scotland.

CORRESPONDENCE.

SOURCE OF AUSTRALIAN ARTESIAN WATERS.

SIR,—In your September issue your reviewer mentions incidentally Professor Gregory's views on the source of Australian artesian waters. These views are perhaps best illustrated by the following quotations. "Most of the water is an old accumulation, some of which may have been derived by percolation from meteoric sources; much of it is probably of plutonic origin; and some of it may be old sea-water from the Cretaceous beds" ("Australasia," pp. 104, 105). "It is therefore possible to explain the occurrence of the deep-water supply in Australia independently of the present rainfall" ("The Dead Heart of Australia," p. 288). I have elsewhere in your columns (November, 1906) shown that the 'plutonic' origin or 'juvenile' state of geyser waters is far from being established. I now desire to show as briefly as possible, from "The Dead Heart of Australia" itself, that much of the data on which Professor Gregory relies, and to which he often gives the value of established facts, is pure assumption. Professor Gregory assumes:—

(*a*) That subterranean waters may be derived entirely from cooling magmas, and that the steam issuing from volcanoes is so derived. (p. 286.)

(*b*) That the majority of important ore-bodies are due to 'plutonic' or magmatic waters, and that, as there are numerous ore-bodies near the Australian artesian strata, there is consequently an abundance of 'plutonic' water beneath. (p. 287.)

(*c*) That, notwithstanding the general synclinal arrangement of the artesian strata (so far as they are known), and the unlimited motive force presumably inherent in 'plutonic' waters, these 'plutonic' waters would be retained within the strata. Mound springs and hot mud springs certainly do occur, but their yield is microscopic compared with the hundreds of millions of gallons the artesian beds are capable of furnishing daily. Further, it is assumed that there is a complete analogy between the retention within the strata of the Australian hot artesian waters and of the oil and gas of the Caspian and Pennsylvanian districts, despite the synclinal arrangement of strata in the former case and the anticlinal arrangement in the latter. (p. 287.)

(*d*) That flowing wells may be due to the pressure of an overlying sheet of impermeable rock, citing in illustration a tin bottle filled with water, the mouth closed with the exception of a pinhole, and pressure *then* applied to the side (p. 289). The analogy is inexact, since the pressure existed before the water-beds were filled with the water they now hold.

(*e*) That the calculations for rainfall, surface evaporation, and percolation in the neighbourhood of Lake Eyre and in Central Australia are applicable to a water-bed there 2000–3000 feet below the surface, or to an intake area far away in Eastern Australia. (p. 325.)

(*f*) That a complete analogy exists between the cold waters of the quicksands of the Kilsby tunnel near Rugby and Australian artesian waters (p. 300), yet the latter have gained heat and hence power.

(*g*) That the disposition, dip, and character of the deep water-bearing beds are so well known as to preclude the possibility of irregularities in bore pressure being due to these factors (pp. 305 et seq.). But, for example, there may exist at no great depth beneath the surface a north-west prolongation of the Palæozoic rocks that outcrop west of Thargomindah. Some little support is given to the supposition by the shallowness of the Tonko bore, only 250 feet deep. An anticlinal arrangement of water-bearing strata on such a granite ridge would, from the flood-waters of the Barcoo and the Diamantina, feed both a Lake Eyre artesian basin and the great central Queensland basin. The geology of the region is, however, unknown.

(*h*) That the salinity of the unknown beds traversed by the underground waters is practically uniform. (pp. 312–314.)

(*i*) That there are known and well-established criteria of 'plutonic' waters; that 'mineral waters' are of necessity 'plutonic' waters; and that the presence of alkaline carbonates in waters is a sufficient guarantee of their 'plutonic origin.' (pp. 315, 316, 339.)

(*k*) That waters heated to no more than 96° to 139° F. are, by reason of their temperature, 'plutonic' waters. (p. 317.)

(*l*) The impossibility of the derivation of the oil or gas of, say, the Alice Downs well from intercalated sedimentary beds. (p. 318.)

(*m*) That tidal wells are entirely analogous to geysers. (p. 328.)

(*n*) The impossibility of water percolating from overlying sedimentaries into fissures in granite (Oxton Downs). (p. 339.)

(*o*) That "if the water be of meteoric origin, it must continually be enlarging the underground fissures" (p. 340), and this despite the weight of 2000–4000 feet of strata already quoted by the author (p. 289) as a sufficient cause of flowing wells.

Professor Gregory throughout assumes—

(*p*) The impossibility of meteoric waters descending to sufficient depths to gain the temperature observed; and

(*q*) The impossibility of the observed gases and contained solids being derived from chemical interaction within the sedimentary strata.

Finally, Professor Gregory loses sight of the great facts that thousands of square miles of the granite through which his 'plutonic' water is supposed to have come is exposed to our investigation, and that the granite is presumably now in exactly the same condition as during the Tertiary period, when his waters were accumulating. While the fissures in the upper 500 feet of this granite contain water, as in the Queensland and Westralian mining fields and in the numerous bores near Camooweal, yet whenever great depths are reached, as the 2,600 feet at Charters Towers, with lesser depths on other Queensland fields, and the 2,000 feet of the Coolgardie bore and the Kalgoorlie mines, the granites and older rocks are dry. But Professor Gregory's theory demands, in view of the daily yield of 450,000,000 gallons, a widespread present distribution in the granite of fissures filled with hot water and extending to great depths.

With the foregoing protest against the elevation of pure assumption to the commanding position of ascertained fact I am content to leave the full discussion of the subject to the capable pens of my former colleagues in Australia, who have had a wider personal knowledge of the artesian area than I possess. MALCOLM MACLAREN.

NOMENCLATURE OF AUSTRALIAN SILURIAN OPHIURIDS.

SIR,—A few points in Dr. Bather's article "Australian Palæontologists on Silurian Ophiurids" call for further comment. Taking Dr. Bather's remarks *seriatim*, it would appear that I had flagrantly transgressed certain established rules of nomenclature, since he says that I seem "for the moment to have forgotten the perfectly definite and, one had thought, universally accepted rule of nomenclature, according to which the genus must follow its genotype. In other words, *Sturtzura* must become a simple synonym of *Protaster*." In changing the genotype, reference was made to the Stricklandian Code of Rules of Zoological Nomenclature (which forms the basis of the several later codes), where, in paragraph 5, it says: "When the evidence as to the original type is not perfectly clear and indisputable, then the first person who subdivides the genus may affix the original name to any portion of it at his discretion," etc. In the present instance, however, Professor Gregory did select the genotype, but had the conception that the arm-structure was similar to the accompanying form, *leptosoma*. Since, therefore, the genotype was selected in error, it is necessary to follow an unwritten, but nevertheless, patent rule, reforming the genus thus broken up, and instituting the only remaining form—regarded as congeneric, be it remembered, by Gregory—as the valid claimant. The Stricklandian rule quoted above should afford sufficient authority and reason for such procedure, otherwise rules of nomenclature, made with the best intent, may easily prove a stumbling-block to scientific progress, and a cause of confusion, instead of a simplifying of scientific terminology.

In the interpretation of the lateral ossicles in the two species of *Sturtzura*, it may be more convenient to regard the curved, fusiform ossicles as an intermediate series—derived from a boot-shaped ambulacral, but now perfectly distinct—and to still refer to the spine-bearing plate, as Dr. Bather suggests, as the adambulacrals. In fact, there seems a transitional tendency shown in these forms, from the typical Protasterid towards a Lapworthurid, especially as there is some indication of the ventral arm-ossicles tending to become parallel on the distal and proximal margins.

Dr. Bather's suggestion that *Sturtzura* can lapse and be resuscitated under a fresh diagnosis with *S. brisingoides* and another species is surely untenable? As the original genotype is now shown to be a form of *Protaster*, this action would be condemned by the rule adopted by many zoologists of "once a synonym always a synonym" as applying to generic terms.

The last paragraph of Dr. Bather's excellent and suggestive review needs no comment, for no one responsible for museum arrangement would seriously entertain the idea of translating into free English every scientific term on the exhibited labels.

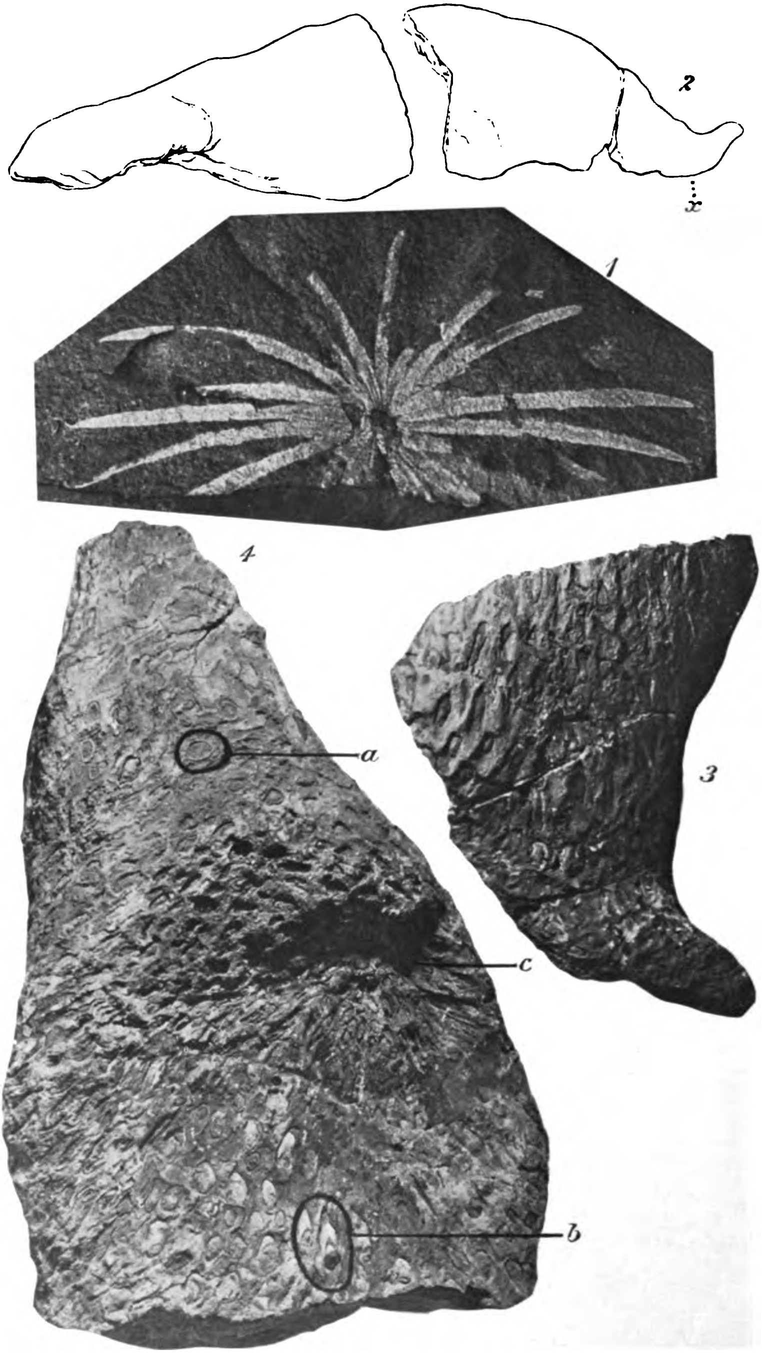
F. Chapman.

National Museum, Melbourne.
August 21st, 1907.

A CORRECTION.

Sir,—In my paper "Notes on the Invertebrate Fauna of the Uitenhage Series in Cape Colony," published in the present volume of the Geological Magazine, July number, pp. 289–295, an inaccurate statement was inadvertently allowed to pass into print. With reference to an assemblage of fossils mentioned on p. 290, the following sentence occurs, commencing on line 21 from the top of the page: "All these, so far as we know, are confined elsewhere to the Cretaceous rocks . . . ." This statement should not, of course, refer to the genus *Solecurtus*, and the sentence should read as follows: "All these, with the exception of *Solecurtus*, are, so far as we know, confined elsewhere to the Cretaceous rocks . . . ." I hope you will be able to give publicity to the correction of this oversight.

F. L. Kitchin.



D. Elliott, Phot.

Fossil Plants from South Africa.

Fig. 1. Phyllotheca. Figs. 2-4. Osmundites.

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ORIGINAL ARTICLES.

I.—Notes on Fossil Plants from South Africa.

By A. C. Seward, F.R.S., Professor of Botany, Cambridge.

(PLATES XX AND XXI.)

THE specimens described in these notes form part of a collection sent to me for examination from the South African Museum, Cape Town; they include the following species:—

Phyllotheca Whaitsi, sp. nov. Uitenhage Series[1] (Wealden). Pl. XX, Fig. 1.
Osmundites Kolbei, sp. nov. Uitenhage Series (Wealden). Pls. XX, XXI, Figs. 2–5.
Glossopteris indica, Schimp. = *Rubidgea Mackayi*, Tate. Permo-Carboniferous.
Lepidodendron australe, M'Coy. Lower Karroo (? Lower Carboniferous). Pl. XXI, Figs. 6–8.
Bucklandia sp., cf. *B. anomala*, Carr. Uitenhage Series. Pl. XXI, Fig. 9.

Phyllotheca Whaitsi, sp. nov. (Pl. XX, Fig. 1.)

The specimen represented in Fig. 1 was found by Mr. J. A. Whaits at Prince Albert in shale lying between the Witteberg Series and the Dwyka conglomerate: it consists of a single whorl of leaves of which the longest has a length of 4·5 cm. and a breadth of 3 mm. The linear segments converge towards a narrow axis about 5 mm. in diameter; they show faint indications of a midrib and have acuminate apices.

In spite of the fact that Fig. 1 represents the only example so far discovered I propose, for the sake of convenience, to describe it under a new name, thus placing on record Mr. Whaits's contribution to our knowledge of a flora the discovery of additional records of which would be of exceptional interest. It must, however, be admitted that the specimen for which the generic title *Phyllotheca* is chosen hardly affords satisfactory evidence as to its affinity.

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[1] For an account of the Uitenhage flora see Annals South African Museum, vol. iv, 1903.

Osmundites Kolbei, sp. nov. (Pl. XX, Figs. 2–4; Pl. XXI, Figs. 5*a–d*.)

The material on which this species is founded was obtained from the Uitenhage Series at Herbertsdale in Cape Colony and presented to the South African Museum by Mr. Kolbe. It consists of several pieces of what appears to have been a large stem reaching a length of about 90 cm. The outline drawing reproduced in Fig. 2 from a photograph sent to me from the Museum by Miss Wilman shows the curious shape of the fossil, tapering to a blunt point at one end and flatter and broader at the other; Figs. 3 and 4 illustrate the surface features as seen on portions of the weathered stem. The smaller piece (Fig. 3) represents the narrow end of the specimen (*x*, Fig. 2); the side seen in the photograph shows the remains of petioles, and on the reverse side numerous sinuous roots occur in association with the bases of leaf-stalks. The roots are approximately circular in section, the portion preserved being the resistant sclerenchymatous sheath which surrounded the central cylinder. Fig. 4 shows a larger portion (33 cm. long) of the stem represented in outline in Fig. 2; the section of the broader end, which is considerably flattened, measures 20 by 6 cm.: at *c* there is a well-marked depression towards which the petioles converge and gradually become smaller in diameter, suggesting the position of a branch apex. On the weathered surface of the block shown in Fig. 4 petiole-bases are seen at various angles and differing therefore in outline: a petiole section exposed at *a*, Fig. 4, and enlarged in Fig. 5*a*, displays the vascular strand of the main axis of the frond as a broad U with the free ends curved inwards; the ridge forming the outer boundary of the petiole no doubt owes its prominence to a band of sclerenchyma which formed a protective and strengthening covering to the leaf-stalk. The form of the vascular strand of a smaller and presumably younger leaf is shown in Fig. 5*b*, and Fig. 5*c* represents a partially crushed petiole (enlarged 3 times) with a flattened U-shaped vascular strand. The petioles exposed at *b*, Fig. 4, are seen more clearly in Fig. 5*d*. There is a close resemblance between this specimen, as regards the structure of the petiole-bases, and *Osmundites Dowkeri*, Carr., from the Lower Eocene of Herne Bay.[1]

The material on which the above description is based is now in the hands of my friend Mr. Kidston, to whom it was sent in the hope that the new species might be more fully described in the monograph on Fossil Osmundaceæ on which he is engaged in collaboration with Mr. Gwynne-Vaughan.[2] Mr. Kidston tells me that a preliminary examination of sections has revealed the presence of tissues in a fairly good state of preservation and confirmed the identification of the stem as a species of *Osmundites*.

In its dimensions and in the branching indicated in Fig. 4 the fossil stem resembles that of the recent species *Todea barbara*, Hook.,[3] an Osmundaceous fern which occurs in South Africa, East Australia, and the North Island of New Zealand. The similarity extends to the form and arrangement of the petioles and their vascular strands. It is noteworthy that with the stem were found imperfectly preserved impressions of *Cladophlebis denticulata* (Brongn.) and *C. Browniana* (Dunk.). I have elsewhere suggested that *C. denticulata*[1] is most probably Osmundaceous, and others[2] have expressed the same opinion. Though we have as yet no satisfactory proof of the correctness of this view it receives some support from the discovery of the stem which it is proposed to name *Osmundites Kolbei*. It is interesting to find that a petrified Osmundaceous stem recently described by Messrs. Kidston and Gwynne-Vaughan as *Osmundites Dunlopi*[3] from Jurassic beds in the Otago district, New Zealand, was also found in association with impressions of *Cladophlebis denticulata*.

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[1] Carruthers: Quart. Journ. Geol. Soc., vol. xxvi (1870), p. 349, pl. xxiv.

[2] The first part of this work was published a few months ago by the Royal Society of Edinburgh in vol. xlv of the Transactions.

[3] Seward & Ford: Trans. Linn. Soc., 1904, p. 173.

"*Rubidgea Mackayi*," Tate [*Glossopteris indica*, Schimp.].

In Tate's paper "On some Secondary Fossils from South Africa" the following passage occurs:—"With the above-mentioned specimens [i.e. *Glossopteris Browniana*, Brongn.] from Bloemkop are some of an apparently, at first sight, second species of *Glossopteris*; these do not exhibit fructification. Dr. Rubidge has, however, communicated a drawing (by Mr. M'Kay) of a specimen of this species obtained by Mr. M'Kay from East London, and I find that it presents characters generically distinct from those of *Glossopteris*; for the position of the fructification is indicated by a few large elevated regions, arising from many veins, and somewhat regularly arranged in a row coincident with the margin, and not by numerous spots, small in size, supported by one vein, distributed over much of the surface of the frond."[4]

The original drawing of the type-specimen of *Rubidgea Mackayi*, reproduced in Tate's paper, is in the Museum of the Geological Society of London, but the actual specimen is not in the collection. The portion of leaf shown in the figure closely resembles a *Glossopteris* frond, except in the absence of lateral anastomoses between the secondary veins; as Mr. Arber[5] points out, it is impossible to determine the plant accurately without seeing the original specimen.

The plants sent to me from the South African Museum for examination include a few impressions collected by M'Kay from East London and labelled by him. On one specimen is written—"A new species of fern named after Dr. Rubidge from G. M'Kay, East London." This is an imperfect impression, 10 cm. long, on black shale of a fairly broad leaf possessing a distinct midrib, from which numerous secondary veins are given off obliquely; lateral anastomoses are frequent and in some parts of the fossil clearly marked. In size and in the course of the veins the specimen agrees with the drawing of *Rubidgea Mackayi* reproduced by Tate. The supposed fructification cannot be recognised, but there are occasional prominences on the surface of the shale which bear a remote resemblance to those shown in the drawing. It is possible that the drawing was not intended for an accurate copy of the fossil; it is not improbable, however, that the specimen may be the original of a sketch in which imperfections were partially restored and obscure features freely interpreted. Another specimen collected by M'Kay and bearing his label shows some oval and slightly raised areas which bear a closer resemblance to those represented in the drawing. It is hardly necessary to add, the supposed soral impressions have nothing to do with reproductive structures.

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[1] *Ibid.*, p. 253.
[2] Raciborski, "Flora Kopalna": Pamietnika Akad. Umiejetnosei, 1894.
[3] Trans. Roy. Soc. Edinburgh, vol. xlv, pt. 3 (1907), p. 760.
[4] Tate: Quart. Journ. Geol. Soc., vol. xxiii (1867), p. 141, pl. v, fig. 8.
[5] Catalogue of the Fossil Plants of the *Glossopteris* Flora, 1905, p. 54.

The two specimens referred to (Nos. 19 and 16 in the South African Museum) are imperfectly preserved impressions of *Glossopteris* leaves, and I have no hesitation in identifying *Rubidgea Mackayi*, Tate, with *Glossopteris indica*, Schimp.

Lepidodendron australe, M'Coy. (Pl. XXI, Figs. 6–8.)

The impression of which an outline sketch is reproduced natural size in Fig. 6 was found in black shale brought up from a depth of 344 feet in sinking a bore at Elandsdraai, near Orange River station. The specimen was presented by Mr. F. B. Parkinson to the South African Museum. Mr. Du Toit, of the Geological Survey of Cape Colony, who is familiar with the locality, regards the shale as undoubtedly a member of the Dwyka Series (Lower Karroo). The polygonal areas of which the impression consists are approximately 8–9 mm. long and 7–8 mm. broad at the widest part; they are arranged in regular series. A short distance below the apex of each area there is a more or less circular prominence, showing in some cases a central depression as in Fig. 7. On some of the areas shown in Fig. 6 there are indications of a groove extending from the raised scar to the pointed base, as at *g*, *g*.

An examination under a low magnifying power of the thin layer of graphite which covers the greater part of the fossil reveals the existence of the outlines of parenchymatous cells arranged in fairly regular rows converging upwards from the base and sides of the area towards the raised scar. The cells in the region above the scar do not exhibit the same regularity of arrangement as in the lower two-thirds of the field. The general appearance presented by the cell-impressions is seen in a slightly diagrammatic form in Fig. 7, and a few of the cell-outlines are shown as a camera-lucida drawing in Fig. 8. In examining the graphitic layer I made use of a method recently described by Professor Nathorst[1]; a few drops of collodium were placed on the surface of the fossil, and after a short interval the film was removed and mounted on a slide. The addition of a stain facilitated the microscopic examination and the drawing of the collodium film.

The impression is probably that of a stem of the type known as *Lepidodendron australe*, M'Coy, or *Lepidodendron nothum*, Ung., of some authors. The cell-outlines on the surface of the polygonal areas may be those of the epidermal layer, but they were more probably formed by a subepidermal tissue; the scar, which interrupts the continuity of the flat surface, may mark the position of a leaf-base, or, assuming a partial decortication to have occurred prior to fossilisation, the scar may represent a gap in the cortical tissue caused by the decay of delicate tissue surrounding the vascular bundle of each leaf in its course through the cortex of the stem. Gaps of this nature are characteristic features in tangential longitudinal sections through the outer cortex of petrified Lepidodendron stems from the English Coal-measures. The indication of grooves seen on some of the areas (Fig. 6, *g*, *g*.) may mark the course of the vascular bundles passing inwards and downwards through the cortex. If the impression (Fig. 6) were that of the actual surface of a Lepidodendron or a Sigillaria stem we should expect to find traces of the parichnos (a strand of tissue which accompanies the leaf-bundle of these plants and forks into two arms just below the base of a leaf) appearing on the leaf-scar as two small scars, one on each side of the scar of the leaf-bundle. In the specimens from Vereeniging described in 1897[1] as *Sigillaria Brardi*, which bear a superficial resemblance to the Elandsdraai fossil, the parichnos is clearly shown. On the other hand, an impression of a partially decorticated Lepidodendroid stem need not necessarily show the parichnos as a distinct feature: owing to its close association with the leaf-trace in the outer cortex, before its separation in the form of two diverging arms, it would not appear as a distinct gap apart from that representing the leaf-bundle.[2] The absence of the parichnos may be regarded as a point in favour of the view that the impression is that of a partially decorticated stem. Similarly, the absence of any demarcation between a leaf-cushion and a true leaf-scar such as characterises the stems of Lepidodendra and many Sigillariæ is also favourable to the same interpretation. The fact that a partially decorticated stem often presents an appearance comparable to that of serially disposed leaf-cushions is in some instances due to the presence of a reticulum of thicker-walled elements in the outer cortex, which divides up the thinner-walled tissue into regular meshes or areas corresponding approximately in shape to the leaf-cushions. It may be that the dark band, *x*, shown in Fig. 7, is the impression of some of the fibres composing a reticulum of strengthening tissue. It is, however, possible that the cells seen in Figs. 7 and 8 may be those of the epidermal layer, and the absence of a parichnos may constitute a definite character, but this is on the whole less likely than the other hypothesis. Although we cannot feel much confidence in the specific determination of stems which have probably lost part of their surface features, we may briefly refer to other specimens which bear a close resemblance to the African fossil.

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[1] Arkiv för Botanik (K. Svensk. Vetenskaps Akad. Stockholm), vol. vii, No. 4, 1907; also Geol. Fören. Förhandl., vol. xxix, Häft 4 (1907), p. 221.

In 1872 Mr. Carruthers[3] described some Palæozoic impressions from Queensland, some of which appear to be identical with that shown in Fig. 6 under the name *Lepidodendron nothum*, Ung. The material on which Unger founded this species[1] was obtained from Thuringian rocks referred to an Upper Devonian horizon; the surface showed the remains of spirally arranged rhombic areas similar to those of the African specimen, and the anatomical structure was compared by Unger with that of *Lepidodendron Harcourtii.* Solms-Laubach,[2] on examining Unger's type-specimen, found that the comparison was based on a misinterpretation, and that the supposed surface-features are those of a partially decorticated stem.

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[1] Seward: Quart. Journ. Geol. Soc., vol. liii (1907), p. 326, pl. xxiii.

[2] For figures of the parichnos strand see Williamson, Phil. Trans. Roy. Soc., 1893.

[3] Carruthers: Quart. Journ. Geol. Soc., vol. xxviii, 1872.

The Queensland fossils are considered by Carruthers, whose opinion is supported by Solms-Laubach,[3] as specifically identical with Dawson's *Leptophlœum rhombicum.*[4]

M'Coy[5] instituted the name *Lepidodendron australe* for some specimens found in rocks of Lower Carboniferous age in Victoria, Australia; the fossils so designated are regarded by many authors as identical with the Queensland specimens of Carruthers. It seems clear that the Queensland and Victoria fossils should be described under the same name, but, as Kidston[6] has pointed out, it is by no means certain that Carruthers was correct in referring his specimens to Unger's species.

An examination of the material described by Carruthers and of the figures published by Feistmantel[7] and other authors leads me to apply M'Coy's specific name to the impression from South Africa. A similar, though probably not an identical, plant has been described by Krasser[8] from China, and from the Devonian of Spitzbergen Nathorst[9] has figured an impression under the name *Bergeria*—a term employed for certain forms of decorticated Lepidodendron stems—which appears to be identical with the Australian type. From the Lower Carboniferous strata of the Argentine Szajnocha[10] describes another example of this form of stem as a Lepidodendron of the *Lepidodendron nothum* group. For a full account of *Lepidodendron australe*, from the point of view of its identity with *Lepidodendron nothum* and as regards its geological range, reference may be made to a paper by Mr. Etheridge,[11] as also to one by Messrs. David & Pittman.[12]

As M'Coy originally pointed out, his species *Lepidodendron australe* agrees closely with a Lepidodendron stem in the Bergeria condition. It may be that the numerous specimens included under his species are impressions of stems which have lost their superficial tissues. Until more is known as to the structure of these plants we cannot be certain as to generic position. Assuming the fossils to be those of

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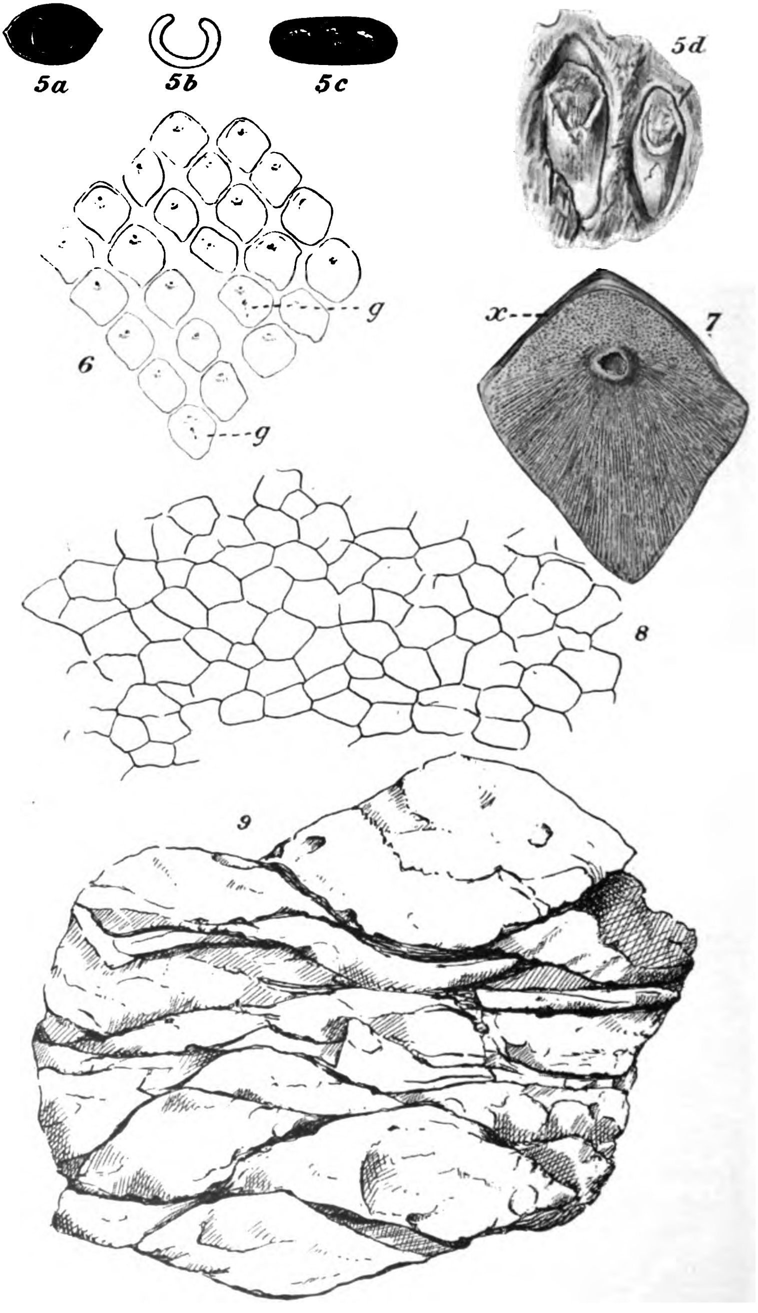
[1] Unger: Denksch. k. Akad. Wiss. Wien, xi (1856), p. 175.
[2] Solms-Laubach: Abh. k. Preuss. geol. Landesanst., Heft xxiii, 1896.
[3] Fossil Botany, 1891, p. 200.
[4] Dawson: Geol. Surv. Canada, 1871, pl. viii.
[5] M'Coy: Prod. Pal. Victoria, dec. i, 1874.
[6] Kidston: Catalogue of the Palæozoic Plants in the British Museum, 1886, p. 231.
[7] Feistmantel: Mem. Geol. Surv. N.S. Wales, Palæont., No. 3 (1890), pl. ii.
[8] Krasser: Denksch. k. Akad. Wiss. Wien, Bd. lxx (1900), pl. ii, fig. 1.
[9] Nathorst: K. Svensk. Vetenskaps Akad. Hand., xxvi, No. 4, pl. ii.
[10] Szajnocha: Sitzber. k. Akad. Wiss. Wien, Bd. C, Abth. i (1891), p. 203.
[11] Etheridge: Rec. Geol. Surv. N.S. Wales, vol. ii, pt. 3.
[12] David & Pittman: *ibid.*, vol. iii, pt. 4.



E. Wilson, del. (5-8)
M. Seward, del. (9)

Fossil Plants from South Africa.

Fig. 5. Osmundites. Figs. 6-8. Lepidodendron. Fig. 9. Bucklandia.

a Lepidodendroid plant—an assumption supported by such evidence as we possess—we are hardly in a position to say that *Lepidodendron* is a more appropriate generic designation than *Sigillaria*. As regards the geological range of *Lepidodendron australe*, it is perhaps more especially characteristic of Lower Carboniferous rocks, though it occurs also in Upper Devonian strata.

Bucklandia sp., cf. *B. anomala* (Stokes & Webb). (Pl. XXI, Fig. 9.)

The specimen represented in Fig. 9 was obtained from the Wood bed of the Uitenhage Series on the Witte River: it is a flattened and somewhat crushed piece of a stem covered with tangentially elongated leaf-bases varying considerably in size. The largest base, shown in the upper part of the Figure, is 2 cm. deep and 3·5 cm. wide; those in the middle of the fragment are much narrower in a vertical direction. It is probable that the striking difference in size, which is much more marked on the side shown in the figure than on the other surface, though partly the result of crushing, may indicate the existence of two kinds of leaves as in recent species of *Cycas* and in the stem figured by Carruthers[1] from the Hastings Sands of Sussex as *Bucklandia Mantellii*, a designation which it has been suggested should be changed to *Bucklandia anomala* (Stokes & Webb).[2] The specimen is worth recording as the first example of a Cycadean stem discovered in the plant-beds of the Uitenhage Series, which have afforded several types of Cycadean fronds.[3]

EXPLANATION OF PLATES XX AND XXI.

FIG. 1. *Phyllotheca Whaitsi*, sp. nov. Slightly reduced.

FIGS. 2–5. *Osmundites Kolbei*, sp. nov.

- Fig. 2. Outline drawing showing the shape of the stem. Approximately ⅒ nat. size.
- Fig. 3. Terminal piece of the stem (*x*, Fig. 2).
- Fig. 4. Portion of the stem (⅓ nat. size) showing petiole-bases and depression (*c*).
- Fig. 5*a*. Transverse section of petiole (*a*, Fig. 4).
- Fig. 5*b*. Transverse section of vascular strand of younger leaf-stalk.
- Fig. 5*c*. Leaf-stalk with crushed vascular band.
- Fig. 5*d*. Oblique view of two petiole-bases (*b*, Fig. 4).

FIGS. 6–8. *Lepidodendron australe*, M'Coy.

- Fig. 6. Nat. size.
- Fig. 7. A single area enlarged.
- Fig. 8. Cell-outlines (considerably enlarged) as seen on the surface of the area shown in Fig. 7.

FIG. 9. *Bucklandia* sp. 1⅓ nat. size.

II.—THE TYGERBERG ANTICLINE.

By Professor ERNST H. L. SCHWARZ, A.R.C.S., F.G.S.,
Rhodes University College, Grahamstown, South Africa.

(PLATE XXII.)

ROUND the south-western corner of Cape Colony there is a belt of mountains which exhibit a number of exceedingly interesting features. The ranges meet almost in a right angle, the one set trending north and the other east, from a point near Ceres village; this is what Suess calls a 'Schaarung,' and I believe nowhere else in the world does this structure show itself in such a simple manner. Each range is composed essentially of an S-shaped bend, the syncline on the coast side and the anticline on the inner side, while subsidiary folds are added in various places, without, however, obscuring the general nature of the mountain structure. The central axes of the ranges are composed of a coarse grey false-bedded sandstone, the Table Mountain Sandstone resting on the outer side on Pal-Afric beds, slates, phyllites, and intrusive granite, and dipping under later and conformable beds on the inner sides. The age of the Table Mountain Sandstone is uncertain, as, with the exception of indeterminable bivalves found by Griesbach in Natal and possibly a *Patella*, no fossils have been recorded from the series; the overlying beds, however, the Bokkeveld Beds, contain a rich fauna belonging to the American type of Devonian species. On top of the Devonian comes another series of sandstones, the Witteberg Beds, strongly differentiated from the older sandstone series by their yellow and red tints, and the amount of shaly matter intercalated between the sandstone banks. The Witteberg Beds, although strictly conformable to the Bokkeveld Beds, contain a flora which is referable to the Lower Carboniferous, the conformity being supposed to be the result of the ocean floor, during the period occupied elsewhere with the deposition of the Middle and Upper Devonian, having sunk below the area, or rather out of reach of deposition of land detritus. The Witteberg Beds usually form a fronting range of hills separated from the main ranges by a valley occupied with the softer slates and limestones of the Bokkeveld Series. On top of the Witteberg Beds come the series of the Karroo system, commencing with the Dwyka and Ecca; these either form wide flats or a country cut up into small hills or kopjes.

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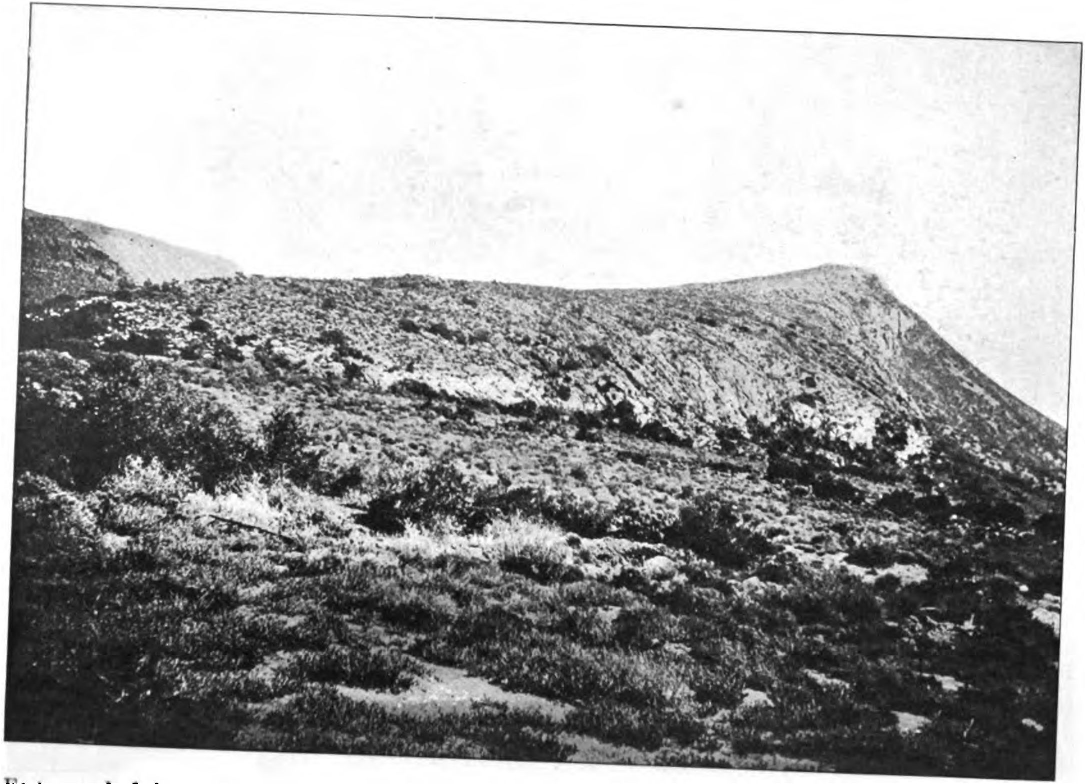
[1] Carruthers: Trans. Linn. Soc., vol. xxvi (1870), pl. liv, fig. 4.

[2] Seward: Catalogue of the Mesozoic Plants in the Department of Geology (British Museum): The Wealden Flora, pt. ii, p. 123.

[3] Seward: Ann. S. African Museum, vol. iv (1903).

The main ranges thus tower up to 6,000 feet, rarely to 7,000 feet, above plains elevated not more than 1,000 feet, and the abrupt flanks have been carved into tremendous gorges or kloofs by the streams that rush down them when it rains. The axes are usually fairly even as seen against the skyline, but the central ridge is often so narrow that the streams from either side have cut back beyond the watershed and have thus isolated peaks which assume fantastic, pinnacled, and castellated forms. The hillsides, where not periodically burnt, support a luxuriant heath vegetation, the Ei or Heide veld, consisting of a large number of sugar bushes, *Proteas*, and woody Compositæ, while in among these are the beautiful Cape heaths and everlasting flowers; in two districts there are added the noble Cape cedars, *Cullitris juniperoides*, on the north-west, and *C. schwarzi*, which I discovered in the out-of-the-way valleys of Baviann's Kloof, on the south-east. The wildness and beauty of the mountains have called forth admiration from every European who has climbed among them, and they have been likened from a scenic point of view to the Alps, but from a geological point of view they are entirely different.

The Alps are mountains that have been folded and the folds themselves again folded; in the coast ranges of the Cape the first stage has alone been reached. The difference is that between an



Eastern end of the Tygerberg anticline; the bare dip-slopes of the Witteberg quartzites are seen rising from the plain cut in Dwyka Conglomerate.

anticlinorium and an anticline. And whereas on the Alps the prodigious force has crumpled a whole succession of formations and has allowed recumbent folds to develop, in the coast ranges of the Cape there has been only a single formation folded into the main range, and where an overfold has taken place it is of restricted extent. All the subsidiary folds that develop on the inner or 'stoss' side of our ranges are upright folds, and I wish to lay stress on this point because the large number of papers recently written on recumbent folds in and around the Alps has directed attention to this peculiar feature. Dr. C. Sandberg has ascribed such an origin for the abrupt range of quartzites that rise from the plains north of Prince Albert,[1] in spite of the photograph illustrating the nature of the range which Mr. Rogers published in his "Geology of Cape Colony," p. 141. In the accompanying photograph (Plate XXII) I show the eastern end of the Tygerberg, as this sharp crest is called, where the bare dip-slopes of quartzite are seen rising from out of the plain, composed of Dwyka conglomerate, almost as if they had been made of sheets of some pliable metal like zinc. There are features of interest enough in the Tygerberg without suggesting the additional one of recumbent folds, and however much I should like, for the sake of the interest which such a structure would evoke, that Dr. Sandberg was right, yet if the structure of the coast ranges of Cape Colony is misunderstood, much of the geology of South Africa would become unintelligible.

The difficulty which the Tygerberg presents is that although the quartzites tower up in a narrow vertical anticline, the Dwyka shales and conglomerate around it are only moderately inclined, and indeed in some places lie actually flat. The Dwyka conglomerate is an exceedingly tough, close-grained rock, being in fact a glacial till that has been compressed and hardened by the pressure of some thousands of feet of superincumbent strata now removed by denudation. The Witteberg Beds, on the other hand, show in the extraordinary twists and bends that nearly everywhere characterise the series, that the rock was móbile when deeply buried; the rocks that form the chief bulk of the strata are fine-grained quartzites, and I ascribe this mobility to the fact that silica at temperatures and pressures found in the earth's crust at a depth of a couple of miles is easily soluble. What has happened, then, in the Tygerberg, is that an earth-fold has developed with an east and west trend; the Dwyka conglomerate has yielded but slightly to the folding, but the underlying quartzites were reduced to such a state that they were ready to flow in any direction where there was relief of pressure, the process being one of solution and redeposition of the substance of the individual grains. Eventually the folding became so great that the Dwyka conglomerate had to yield, but instead of bending, a vast rent developed through the strata down to the underlying quartzites. This gave relief of pressure, and the quartzites came squeezing through the gap in the overlying beds much in the same manner that lead may be made to flow between the jaws of a vice. The process in the case of the Tygerberg was naturally an exceedingly slow one and was accomplished at considerable depth beneath the earth's surface; the flow of quartzite can only take place at certain temperatures and pressures, and directly these fall below a certain point, solution and redeposition of the substance of the constituent grains cease, and the rock becomes the hard, brittle, intractable rock one is familiar with.

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[1] Trans. Geol. Soc. South Africa, vol. ix (1906), p. 82; *Nature*, August 22nd, 1907, p. 423.

If I am wrong in my explanation of the causes which led to the formation of the Tygerberg anticline, I am quite sure that my description of the effects produced is correct; I visited the hill many years ago before I had studied the main ranges to the south, but could make nothing of the difficulties, although I had Sawyer's map and sections[1] with me and found them correct; it was only later that I began to see the nature of the fold after spending a considerable time at the place.

Turning to the larger mass of Witteberg Beds to the south which form the range of hills fronting the Swartebergen, the beds are perfectly exposed in the many kloofs, while there is very little vegetation to obscure the details. One can trace each individual stratum, and the whole series is accounted for; there is no break in the succession whence the root of the supposed overfold could have originated. The same is true of the main range of the Swartebergen, for it is just in this longitude that there is the magnificent gorge, called Meiring's Poort, where the structure of the mountain strata is so clearly revealed that there is no possibility of the existence of a great limb missing. Contrariwise, on either end of the Tygerberg the Dwyka and Ecca Beds are folded in a gentle anticline continuing that of the quartzite.

III.—Inclusions in some Volcanic Rocks.

By J. Allan Thomson, B.A., B.Sc., F.G.S.

My attention was first drawn to this subject by the study of a remarkable crystal breccia, occurring at Kakanui, New Zealand, of which a description is given below. The only similar phenomena I could read of in the Colonial libraries at my disposal were those of the diamond pipes at Kimberley, described by Professors Carvill-Lewis, T. G. Bonney, and Miss Raisin in this Magazine.[2] Having since had the opportunity, thanks to the hospitality of Professor Lacroix, of studying in his laboratory at Paris, I found that the proper discussion of this subject comes under the study of the inclusions of volcanic rocks, of which he has given so admirable an account in his book "Les Enclaves des Roches volcaniques."[3] At his recommendation I collected some inclusions from the well-known dolerite of Portrush, and studied them under his guidance. The present paper consists of a discussion of rocks from these two localities, with descriptive notes on a few other inclusions that I have in my collection.

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[1] A. R. Sawyer, Report on the Geology and Mineral Resources of Prince Albert: Parliamentary Report, Cape Town, 1893.

[2] Numerous scattered references to crystal tuffs occur in British petrological literature, and the subject is well presented by Sir A. Geikie in "The Ancient Volcanoes of Great Britain," especially vol. i, p. 62, and vol. ii, p. 79, but the general paucity of information on this point in the standard textbooks is remarkable.

[3] A. Lacroix: "Les Enclaves des Roches volcaniques": Macon, 1893.

Two things stand out clearly from a cursory examination of this book, the frequency, almost the universality, of inclusions in igneous rocks, and the importance of the aid which they afford to the student of volcanic phenomena. Under these circumstances, it is remarkable how long this branch of study has escaped attention from British geologists. Lacroix's useful nomenclature has not been adopted in our literature, although Phillips, Teall, Sollas, Harker, Judd,[1] and others have paid considerable attention to some varieties of inclusion, and Harker has established a slightly different classification of these phenomena.

Before proceeding to actual descriptions it will be of advantage to outline Lacroix's terminology and most important conclusions, and to correlate the terms already in use. Lacroix establishes two classes:—

A. *Enclaves enallogènes.*
B. *Enclaves homœogènes.*[2]

A.—The first, *enallogenous inclusions*, are without any genetic relation to their host, but are merely accidental inclusions of rocks which the magma has been able to pick up in its progress to the surface.

B.—The second class, *homœogenous inclusions*, are not mere accidents, but are considered to be related to their host in that they have crystallized from the same magma in depth. The best known type are the olivine nodules of basaltic rocks.

Zirkel, following Sauer, uses the terms *Einschlüsse endogene* in the sense of Lacroix's *enclaves homœogènes*, and insists on the difference between such inclusions and the basic secretions (*Schlieren*) of granitic rocks.[3] Doelter makes a similar division into *exogene* and *endogene*, correlating these with Lacroix's *enallogène* and *homœogène*.[4] But in many recent descriptions German authors have preferred the latter terms.

In English scientific literature the term *xenolith* has practically established itself in the sense of an enallogenous inclusion. It was proposed by Sollas in his paper on the rocks of Carlingford,[5] while individual crystals derived from foreign sources were called *xenocrysts* to distinguish them from phenocrysts.

Harker, in a paper on mixed rocks,[6] and in his memoir on the Skye rocks,[7] distinguishes *accidental* and *cognate* xenoliths. In the latter "there is a genetic relationship between the enclosed and the enclosing rocks, and here the xenoliths have probably a deeper significance." For scattered crystals of foreign origin he uses the term *sporadic xenocrysts*. This 'genetic relationship' of cognate xenoliths to their host is not to be confused with that of homœogenous inclusions. They are to be understood as fragments of rocks already consolidated which belong to the same petrographical province. Thus the inclusions of gabbro in granite in Skye are considered cognate xenoliths. Lacroix regularly includes such cases amongst the enallogenous inclusions.

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[1] For a discussion of the subject in 1893 and previous literature see Judd, Q.J.G.S., vol. xlix (1893), p. 175.

[2] Ἔναλλος = different; ὅμοιος = similar; γεννάω = to beget.

[3] F. Zirkel: "Lehrbuch der Petrographie," 2nd ed. (1893), vol. i, p. 794.

[4] C. Doelter: "Petrogenesis," 1906, ch. vii, p. 101.

[5] Trans. Roy. Ir. Acad., vol. xxx (1894), p. 493.

[6] A. Harker, "Igneous Rock Series and Mixed Igneous Rocks": Journal of Geology, Chicago, 1900, p. 389.

[7] A. Harker, "The Tertiary Igneous Rocks of Skye": Geol. Surv. Mem., 1904, p. 351.

Judd, in describing the *glomeroporphyritic* structure of the Fair Head dolerite, says[1]: "Those who regard the enclosures composed of olivine, enstatite, augite, etc., which are found in some basalts as having separated at some period from the magma, out of which the surrounding rock was itself formed, may regard these as examples of the glomeroporphyritic structure on a gigantic scale." Conversely, we may regard the small groups of anorthite and olivine crystals, with the structure of troctolite, which lie scattered through the dolerite, as homœogenous inclusions of small dimensions.

Throughout this paper, then, I shall speak of inclusions as enallogenous or homœogenous, dividing the former into xenocrysts and cognate or accidental xenoliths.

The study of xenoliths is important because of the alterations that they have undergone under the influence of the enclosing magma. In other words, they furnish the best materials for the study of the contact metamorphism, both exogenous and endogenous, of volcanic rocks.[2] It is rare to find strongly marked contact phenomena at the junction of volcanic rocks with older rocks, but even where this is the case, as with the Portrush rock described below, the inclusions generally show the same phenomena more strongly marked and more easily studied. Lacroix has found from the study of these inclusions that a broad division of volcanic rocks must be made into the two classes *trachytoid* and *basaltoid*. The former contain orthoclase or acid triclinic felspars, the latter are without these minerals. This division is set up because in the former the modifications undergone by the inclusions are often intense, are of a chemical order, and can only be explained by the presence of *mineralisators*, while in the latter the metamorphic phenomena are less intense and could be produced by the action of heat alone, or, if of a chemical order, are limited to the surface of the inclusions.

The absence of mineralisators in basaltoid lavas is to be explained by their more complete fluidity, permitting of the escape of the gases. That mineralisators are present with the magmas in depth has been shown by Lacroix in his study of the ophites and lherzolites of the Pyrenees.[3] The trachytoid lavas, on the other hand, being much more viscous and cooling more slowly, have not had their gases disengaged so fast, so that these have had time to act chemically on the inclusions and to determine the formation of many minerals—mica, orthoclase, etc.—that cannot be reproduced artificially by pure fusion alone.

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[1] Q.J.G.S., vol. xlii (1886), p. 71.

[2] Lacroix has summed up his conclusions on this subject in a paper "E'tude sur le Métamorphisme de Contact des Roches Volcaniques": Mémoires présentés par divers savants à l'Académie des Sciences, tome xxxi (1894), No. 7.

[3] See A. Lacroix, "Les Phénomènes de contact de la Lherzolite et de quelques Ophites des Pyrénées": Bull. Carte Géologique de la France, No. 42 (tome vi, 1895), ch. iii, p. 124.

It is noteworthy that this division of volcanic rocks corresponds with that established by the work of Fouqué and Levy on the synthesis of igneous rocks. The basaltoid rocks can all be reproduced by fusion and suitable re-cooling, the trachytoid cannot.

The study of homœogenous inclusions is of interest because of the light they throw on the relations between volcanic and plutonic rocks. The inclusions may be divided into two classes, those which possess the same mineral assemblage and practically the same chemical composition as their host, and those which are formed only of the large minerals of the intratelluric crystallisation and are more basic. The former kind are called by Lacroix the *formes grenues* or granular form of the eruptive rock, the second *enclaves basiques* or basic inclusions. As examples of the first may be cited biotite sanidinites in biotite trachyte, and nepheline syenite in phonolites. Sometimes instead of the plutonic rock corresponding to the volcanic host there are found rocks which otherwise occur in association with the former; e.g., camptonites, which so often accompany nepheline syenites, are found in the phonolites of Mont Dore. As examples of the basic inclusions, the olivine nodules of basalts may be taken. The generalisation may be made that in trachytoid rock the 'formes grenues' of the host are more frequent and the basic inclusions rare, whilst in basaltic rocks the reverse is the case. For a discussion of the mode of origin of homœogenous inclusions reference must be made to Lacroix's book. He admits that here similar phenomena may be arrived at in different ways.

The following descriptions are all of inclusions in basaltoid rocks:—

I. Inclusions of the Dolerite Sill of Portrush, Co. Antrim, Ireland.

This rock is so well known and has been so often noticed that a description of it would be out of place here. Sir A. Geikie[1] has remarked the fine grain assumed by the otherwise coarsely crystalline dolerite near its junction with the Lias shales, and Professor Cole has given a description of the microscopic structure of both types in his suggestive account of the contact phenomena.[2] The inclusions examined by me are all from the coast section, and include holocrystalline nodules from the coarse dolerite at the north end of the cape and inclusions of dolerite and Lias from the east side near the junction. Sir A. Geikie mentions the difficulty of distinguishing the basalt and the Lias rocks at the contact; this difficulty is accentuated with regard to the inclusions, for in these the shale has assumed a more crystalline appearance, and inclusions of a flinty type of igneous rock in the dolerite show a great resemblance to sedimentary rocks.

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[1] Loc. cit., vol. ii, p. 299.

[2] G. A. J. Cole, "On Contact-Phenomena at the Junction of Lias and Dolerite at Portrush": Proc. Roy. Ir. Acad., vol. xxvi, sect. B, No. 6, p. 62.

A. ENALLOGENOUS INCLUSIONS.

1. *Cognate Xenoliths.*

Cognate xenoliths have already been noted by Professor Cole in dolerite veins cutting the olivine dolerite.[1] They consist of "the compacter and basaltic layer" which the veins have entered. Those collected by me may be of this category, though I did not observe that the including rock was a vein. They are of a fine dolerite in a coarse one. They are of a grey flinty appearance with frequent crystals of pyrites, and are irregularly mottled with dull greenish patches.

In thin sections they are seen to consist of an aggregate of small felspars, generally in short stout prisms, but often rounded, with patches of irregularly-shaped augite grains, which extinguish simultaneously; it is an ophitic structure in which the optical continuity remains, but the actual continuity of the augite (in section, at least) is broken. It is these plates of augite which give the hand-specimens the mottled appearance. The felspars run from labradorite to anorthite, and preponderate largely over the augite. Olivine is absent. The rock is thus a fine-grained ophitic dolerite. It has suffered no great change from its reheating.

2. *Accidental Xenoliths.*

The alteration of the Lias at its contact by the intrusive dolerite (here basaltic) has been fully described by Professor Cole in the paper already referred to. But near the shore contact it is not uncommon to find patches of the Lias included in the basalt, and where this is the case the contact phenomena are much more marked. Professor Lacroix has observed[2] that along the shore the Lias has been changed to a rock formed mainly of cordierite and extremely rich in crystallites of pyroxene and a little magnetite, with here and there small grains of quartz intact. This alteration is somewhat different to that described by Professor Cole, who has found no cordierite. According to my specimens, the Lias some little distance from the contact contains a good deal of quartz and magnetite and some pyrite in elongated patches, around which is recrystallised quartz, a few scattered flakes of biotite, some chlorite, numerous small granules with a high index which seem to be pyroxene, and a few colourless crystals which may be cordierite; but the fineness of grain and the overlapping of the individual crystals makes identification of all the constituents difficult. A few inches from the actual contact the rock is still fine-grained, but the granules of pyroxene are more recognisable. The rock also contains patches of colourless minerals of larger size, most of which are felspars with Carlsbad twins, but occasionally albite twinning also occurs and anorthite can be recognised. Round the borders of the patches the pyroxene granules are more closely studded and of slightly larger size. Rarely a pleochroic mineral occurs in the patches. From its very great relief and the strength of the birefringence it agrees with staurolite rather than with andalusite, which Professor Cole has found in the contact zone.

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[1] Loc. cit., p. 63.

[2] "Les Enclaves des Roches volcaniques," p. 655.

It is only among the actual inclusions that I have found specimens similar to those described by Professor Lacroix. The presence of cordierite in minute crystals is difficult to verify microscopically unless basal sections are found giving the characteristic twins. In none of my sections can these be found, but they resemble so much Professor Lacroix's sections, which he kindly lent me for examination and in which he was able to obtain this verification, that I do not hesitate to identify as such a mineral occurring abundantly in roughly quadrate plates with straight extinction compared to the direction of elongation. It has in general a lower interference colour than the quartz which is also present, and it is crowded with inclusions of magnetite and fine granules of pyroxene.

Another type of inclusion is quite different from any rock hitherto described from this locality. The hand-specimens differ from the altered Lias only in the presence of streaks of a dull greenish-white colour. In thin sections the darker part is seen to consist of granules of a green pyroxene, much larger than those in the contact specimens, interspaced by colourless prisms and grains of a felspar which occasionally includes the pyroxene. The lighter-coloured streaks are formed, some of felspar with subsidiary wollastonite, some of felspar lime-garnet and calcite, with scattered grains of the green pyroxene. This latter mineral shows an occasional cleavage trace and is faintly pleochroic. Extinction angles up to 42° $(\mathfrak{c} \wedge \mathfrak{C})$ on longitudinal cleavages have been observed. The pleochroism in thick sections is: $\mathfrak{a}$=pale grass green, $\mathfrak{b}$=yellow green, $\mathfrak{c}$=blue green. The felspar is most easily determined in the colourless patches, where it is of largest size. The extinction angles with reference to the trace of the plane of symmetry of the albite twins show it to be anorthite. The lime garnet is confined to a few of the streaks. It occurs in irregularly rounded grains. The wollastonite has a habit not unlike anorthite, from which it may be distinguished by its slightly higher refringence, and by the variable sign of the elongation of its sections; those giving positive elongation, and under convergent light an optic axial cross perpendicular to the elongation, may with certainty be referred to wollastonite. It does not occur in great quantity. The rock therefore consists largely of lime silicates and was probably a calcareous band in the Lias.

The study of these inclusions is thus seen to give valuable aid in the study of the contact phenomena of this rock. Professor Cole suspected wollastonite,[1] but was unable to verify its presence, nor were the colourless granules of sufficient dimensions to furnish him means of determining the felspar. The development of cordierite in the argillaceous inclusions of basaltoid rocks is mentioned by Lacroix as very frequent.[2] In the case of the Portrush rock he considers it "little doubtful that a part of the elements necessary to its formation are of exogenous origin."[3] Limestone inclusions are generally simply calcined, but when silicates are developed they are almost always wollastonite, augite, and garnet.[1] The phenomena exhibited by the inclusions of the Portrush rock are then in complete conformity with the phenomena described by Lacroix.

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[1] Loc. cit., p. 59.

[2] Loc. cit., p. 49.

[3] "E'tude sur le Métamorphisme de Contact des Roches Volcaniques," p. 47.

B. HOMŒOGENOUS INCLUSIONS OF THE COARSE DOLERITE.

These are rounded nodules about an inch and a half in diameter, and can be seen microscopically to consist of augite, felspar, and olivine. Microscopic examination shows that they are holocrystalline with typical ophitic structure, the felspar being idiomorphic towards the olivine as well as towards the augite. The olivine percentage varies, and in the more basic types greatly exceeds that of the augite. The felspar is always abundant and consists of a basic labradorite. Magnetite is the only common accessory. It occurs in one slide in large idiomorphic crystals.

These inclusions do not differ either in mineral composition or in structure from the rocks that enclose them, but they are still more coarsely grained. They are normal ophitic dolerites. They probably represent secretions of the magma at a slightly greater depth, but under almost the same conditions of cooling as the sill.

Professor Cole makes an interesting suggestion with regard to the possibilities of modification of the main mass of the dolerite. While he has identified andesine as the felspar, along the east shore the felspar seems to be always labradorite or anorthite. Clearly, as he says, "there is room for further research in this well-visited and attractive field."

II. Inclusions of the Kakanui 'Mineral Breccia.'

This rock occurs on the sea-coast near the township of Kakanui, Otago, New Zealand. Its general characters and position in the stratified series have been described in a former paper.[2] It is a calcareous stratified breccia of Oligocene age, and contains a remarkable variety of crystalline volcanic products, as has already been noted by Mantell.[3] There is no massive rock in the district that can be directly connected with it, although basaltic puys are abundant in the district, but it contains a few blocks of basaltic rocks which may be assumed to represent the lava-form of the magma by the explosion of which the breccia was formed. Enallogenous inclusions of gneiss, mica-schists, grauwacke, and limestones are not rare, but have not been studied. The chief interest lies in the size and the variety of the minerals, causing a great resemblance to the tuff necks of the Fife coast and to the diamond pipes of Kimberley, and in the nature of the homœogenous inclusions.

The basaltic fragments are not fresh enough to ensure a good determination of the rock, but the two types may be recognised. Both contain pseudomorphs of red rimmed serpentine after phenocrysts of olivine. The augite is fresher and is a pale variety, but is in part replaced by chlorite. A little brown hornblende is present. Calcite is abundant and apparently fills vesicles. The groundmass in both cases is very dark with ferruginous decomposition products. In the first type, a little altered plagioclase felspar is present; the groundmass is more glassy and contains small granules of augite and olivine. The rock has been an olivine basalt. In the other the felspar is absent and the augite in the groundmass is elongated into prisms. The rock appears to have been a limburgite. The character of the homœogenous inclusions strengthens the supposition that the magma has been an ultra-basic one. All the other basalts recorded in the district contain felspars, and in none are the inclusions similar.

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[1] "Les Enclaves des Roches volcaniques," p. 144.

[2] J. A. Thomson, "The Gem Gravels of Kakanui": Trans. New Zealand Institute, vol. xxxviii (1905), p. 481.

[3] Q.J.G.S., vol. vi (1850), p. 324.

The hornblende is generally without any corrosion border, but occasionally well-rounded crystals are found including large crystals of magnetite. It is probably to this corrosion that the polished and rounded surfaces of the hornblende crystals in the tuffs are due. In one slide a large crystal of augite also showed corrosion phenomena.

HOMŒOGENOUS INCLUSIONS.

1. *Isolated Crystals.*

Numerous minerals occur in isolated fragments in the tuffs and breccia, and sometimes attain a tremendous size, especially felspar, hornblende, and a black augite. Garnets, a green augite, biotite, and olivine occur in smaller fragments. The hornblende, garnet, and black augite are sometimes beautifully polished and rounded. With the exception of the felspar these minerals can all be traced to the inclusions described below. Its origin has remained an enigma. It occurs in all sizes up to 70 mm., elongated in the direction of the two principal cleavage faces. Crystal faces are wanting. It is transparent and colourless except where the cleavage planes are coated with calcite, in thin sections perfectly clear and free from inclusions. It is twinned according to both the albite and pericline laws, and the extinction angles and a partial analysis show it to be an acid oligoclase.

2. *Holocrystalline Rocks.*

These occur in great abundance. The commonest type, in fragments with diameters up to eight inches, is an olivine nodule containing much calcite. The more compact types are smaller, and contain olivine only in subsidiary amount. A totally distinct type consists primarily of a black augite and garnet. All these rocks are holocrystalline and granular with fairly coarse texture. None of the elements have crystalline forms, but the spinels and the hornblende which they contain are posterior to the other minerals. They may be conveniently divided into three groups, these being characterised by the presence of spinel and a green augite (diopside or diallage) in the first, a black augite in the second, and predominant basaltic hornblende in the third. The following table will show the different mineral combinations:—

Mineral combinations of Kakanui inclusions.	*Analogies amongst homœogenous inclusions.*	*Analogies amongst plutonic rocks.*
A. (1) Spinel, green augite, olivine ...	Olivine nodules.	Lherzolite.
(2) Spinel, green augite, olivine, brown hornblende	Hornblendic olivine nodules.	Hornblende lherzolite.
(3) Spinel, green augite, olivine, brown hornblende, garnet		Hornblende eulysite.
(4) Spinel, green augite	Pyroxene nodules.	Ariègite.
(5) Spinel, green augite, garnet		Garnet ariègite.
B. Black augite, garnet, with or without hornblende and magnetite	New type of pyroxene nodules.	Basic ariègite.
C. Hornblende, subsidiary garnet, and biotite	Hornblende nodules.	Hornblendite and hornblende ariègite.

The types grouped under A differ from ordinary olivine nodules in the absence of enstatite and the comparative rarity of olivine. Lacroix, however, notes[1] that besides normal olivine nodules there exist more basic types characterised by the presence of brown basaltic hornblende, which moulds all the other elements, and that these are sometimes poor in enstatite and even in olivine and picotite, while the chrome-diopside is replaced by augite. The presence of garnet has not, so far as I can find, been noted in olivine nodules. The green augite resembles the chrome-diopside of lherzolite in colour and in microscopic appearance, but it presents at times an incipient diallage structure. The spinel is generally a green pleonaste, more rarely a brown picotite. This mineral is stated in textbooks to be without cleavage, but in one section a beautiful cubic cleavage may be observed. The garnet is of the pale-rose colour seen in the garnet ariègite of the Pyrenees.

The types grouped under B differ from any well-known plutonic rock or inclusion of volcanic rock. It is still open to question whether they are really homœogenous inclusions, but I incline to this view because of the presence of brown basaltic hornblende and the general similarity of all these rocks to the basic rocks accompanying lherzolite in the Pyrenees. The augite has in hand-specimens a bottle-glass appearance with conchoidal fracture and a jet-black colour, translucent on thin edges. In thin sections it has a pale bistre colour, almost without pleochroism, and a fair cleavage, on which extinction angles up to 41° have been observed. It contains as inclusions regularly arranged rows of rounded or elliptical grains of iron ores, sometimes black and opaque, sometimes translucent and reddish, crossing the cleavage at a considerable angle. The garnet is of a red-brown colour, and is evidently different from that occurring in the types under A.

The commonest type of the rock consists only of the augite and garnet in thoroughly allotriomorphic forms. The augite sometimes includes the garnet, and *vice versâ*. With the incoming and predominance of brown hornblende, which moulds the augite, the rock passes over to the next type.

[1] Loc. cit., p. 486.

Under type C may be grouped all the stages from large crystals of brown hornblende, containing subsidiary inclusions of garnet and biotite, down to the types under B, where hornblende is an accessory mineral.

Another rare type of rock in the breccia seemed to consist of kernels of altered olivine nodules cemented by hornblende and biotite. No material fresh enough for microscopic study could be obtained.

The similarity of olivine nodules to lherzolites has long been known. Lacroix regards them as having been formed by segregation in depth in the basalt magma, forming a crust on the walls of the reservoir that has been broken through on eruption. Although their chemical composition is more basic than that of the basalt which encloses them, and the whole magma could not have crystallised out as lherzolite, yet a considerable mass of the rock might conceivably be formed. In a rock so little felspathic as the Kakanui basalt one is not surprised by their abundance, while the similarity of the other types to the basic rocks found in association with lherzolite is only what might be expected. It will be of interest to demonstrate this similarity.

In his study of the basic rocks accompanying the lherzolites and ophites of the Pyrenees,[1] Lacroix describes two series of rocks: the first, which he has named *ariègites*, always occur associated with the lherzolites; the second, various hornblende rocks, occur as veins in the lherzolite, or in separate bosses. Lherzolite is not always a homogeneous massive rock, but is often banded, at the Etang de Lherz for instance, one band being formed of normal lherzolite, the other of ariègite. It is distinguished from lherzolite by the absence of olivine and enstatite, and consists in the normal type of a monoclinic augite and abundant spinel, while subsidiary types are formed by the presence of garnet and basaltic hornblende. The structure is sometimes like that of lherzolite, sometimes kelyphitic.

The inclusions grouped under A above will be readily seen to resemble in all respects lherzolites and ariègites. It should be remembered that the lherzolite at Lherz contains hornblende.

Under the name of garnetiferous hornblende ariègite is described a rock consisting of brown hornblende, some flakes of mica, and large grains of red garnet with a little magnetite and spinel. The general resemblance of the types placed under C to this rock is sufficiently evident.

The second series of rocks accompanying the lherzolite is very varied, but is characterised by the presence of brown basaltic hornblende as an essential mineral. Among these rocks are hornblendites, pyroxene hornblendites, and hornblende peridotites. The extreme types of inclusion under C may be called hornblendites.

In none of these Pyrenean rocks is there any augite that at all resembles that in the B type of inclusions. The extraordinary colour is probably due to a high percentage of titanium. The rocks do not probably differ much in chemical composition from garnetiferous ariègites.

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[1] Comptes Rendus viii International Geological Congress, 1900, p. 806.

The inclusion of isolated minerals in tuffs and volcanic necks has puzzled many students of volcanic phenomena. In the first place their origin is obscure, as often they cannot be traced to any known rocks; and in the second place, even if they are known in the associated igneous rocks, their size is still a puzzle. Sir A. Geikie says:[1] "The crystals in question seem, however, to point to some chemical process still unknown, which, in the depths of a volcanic focus, under conditions of pressure and temperature which we may speculate about but can perhaps hardly ever imitate in our laboratories, leads to the elaboration of the diamond, garnet, sahlite, smaragdite, zircon, and other minerals." The case of the Kakanui breccia shows at least that the majority of these minerals so often found in tuffs, including the refractory garnet, do form in homœogenous nodules from the volcanic magma. One may even speculate that the origin of the minerals of the Kimberley diamond pipes is due to the same process, and that the associated rocks may be in large part of the nature of homœogenous inclusions.

Homœogenous Inclusion in Greenstone Sill, Cudden Point, Cornwall.

In his discussion of inclusions Lacroix has wisely confined himself almost entirely to the younger volcanic rocks in order to eliminate all phenomena due to later alteration. Now that his conclusions are well established it is of interest to study those of the older volcanics as well. The West Cornish greenstones are very free from inclusions, if we except veining from the granite contacts, but in that of Cudden Point I have found large blocks of homœogenous inclusions. The sill itself has been profoundly affected by pressure and secondary changes, and near its lower boundary consists practically of a schist formed of fibrous hornblende and zoisite, but the original rock was probably an ophitic dolerite. The inclusions have suffered also from these changes, but not nearly to the same extent. They have, as it were, formed eyes (*Augen*) during the production of the schist. They still contain the original augite, ophitically enclosing large plates of plagioclase felspar, which is the predominant element of the rock. In the absence of Carlsbad twins Levy's exact method is not available, while the largest angles of extinction observed on symmetrically lying albite-lamellæ amount to 12°. This would indicate a basic oligoclase, but it is unlikely that the felspar is so acid. One or two of the crystals show a slight zonary banding.

The effects of crushing are seen in the bending of the lamellæ of the felspars and local comminution with production of a granulitic structure. One augite crystal is neatly faulted.

Secondary changes are the production of numerous granules of zoisite in the felspars, and in the growth of a colourless fibrous hornblende from the augite along its boundaries and in its cleavage cracks. Small fibres exist also in the felspars.

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[1] Loc. cit., vol. i, p. 62.

IV.—NOTES ON SOME COASTAL FEATURES IN CO. WATERFORD.

II. WOODSTOWN TO PASSAGE EAST.

By F. R. COWPER REED, M.A., F.G.S., etc.

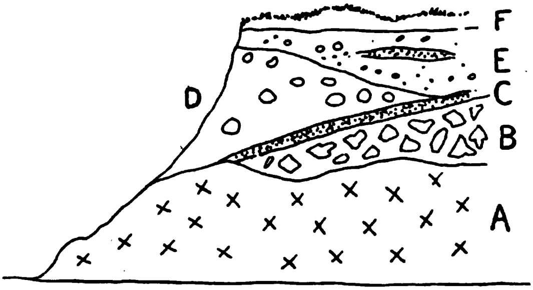
ON a previous occasion (GEOL. MAG., Dec. V, Vol. IV, 1907, pp. 17–20) an account was given by the author of Fornaght Strand in the estuary of the River Suir; and the nature and development of the drift deposits further up the river may now be described.

On the north side of Knockavelish Head (which bounds Fornaght Strand on the north), the coast from Ballyglan is bordered by low sand dunes for a distance of about a mile and a half, and there is no cliff or exposure of any solid rock, the old sea margin being apparently situated now some way inland behind an area of more or less marshy land at the back of the dunes. Traces of the former sea-cliff can, however, be recognised here and there by a sudden slight rise in the ground. A wide flat expanse of sand and mud, known as Woodstown Strand, is uncovered at low tide along this stretch of coast, extending out fully a mile from high-water mark, but so far no trace of the submerged forest of Fornaght has been here discovered.

At the north end of the sand dunes a low cliff of drift commences, and increases gradually in height till it ends against the igneous rocks of Newtown Head in the interesting section given on p. 502. This drift cliff for its whole length to this point is composed of the ordinary Boulder-clay of the district, capped by a bed of sandy yellowish or whitish marl, 1–1½ feet thick, free from included boulders, but not otherwise sharply marked off from the underlying Boulder-clay. Towards the southern end of this line of cliffs, the section is capped by a bed of recent drifted sand, 6 inches to 1 foot thick, passing up imperceptibly into the subsoil and soil, which is mixed with a little vegetable matter. Occasionally short bands or isolated patches of cockle-shells of fairly recent appearance occur in this bed at varying depths below the present surface of the ground. These accumulations of shells must be regarded as due to human agency, though probably of an early date.

At Newtown Head itself, the cliff is 20–25 feet high, and the clayey bed on the top of the Boulder-clay is here replaced by a mass of clayey angular gravel or rubble devoid of bedding, but in places showing small lenses and bands of grey or yellow sand (E). The rock-fragments composing it are of various sizes, and not sorted or rounded, but angular, and of local origin. Probably we may regard this deposit as representing the Upper Head, washed and redeposited by running water. Below this comes the Boulder-clay proper (D), with a thickness of about 12 feet, but it wedges out rapidly against the upward sloping surface of the underlying beds. There seems to be a greater number of included boulders in its upper part (though none are of large size), as if the clayey matrix had been to some extent washed out and carried away.

Immediately beneath the Boulder-clay is a thin but fairly continuous bed of light-coloured sand, varying from 2 inches to 1 foot in thickness (C), and dipping down seawards at an angle of about 20°, roughly parallel to the eroded surface of the solid rock on which the whole series of drift deposits rests. This sandy bed cannot be regarded as equivalent to the 'Blown-sand' of the Cork district described by Messrs. Wright & Muff, for the latter occurs beneath the Lower Head, while at Newtown Head it rests upon the Lower Head (B). It must be regarded as marking a local episode on a sandy shore before the deposition of the Boulder-clay (D). The true Lower Head of Newtown Head occurs immediately beneath this layer of sand, and is composed of large angular fragments of the solid 'greenstone' on which it reposes, imbedded in a very scanty sandy matrix. The blocks are quite irregular in size and arrangement, and are all angular and usually large, measuring up to one foot or more in length, but in one spot the fragments are of a smaller and more uniform size and show rough bedding. This mass of Head (B) rests on an uneven hummocky but rounded surface of 'greenstone' (A), and measures about 6 feet thick at its maximum, being banked up against the old pre-glacial sloping cliff and spread over the irregular rock-platform. In this instructive section at this point the Lower Head is seen to thin out rapidly to the east, so that the Boulder-clay overlaps it and comes to rest directly on the solid greenstone.



Section of Cliff at Newtown Head.

A. Solid greenstone with eroded upper surface.
B. Coarse angular head, composed of unworn fragments of the underlying rock in scanty sandy matrix. ± 6 feet thick.
C. Light-coloured sand. 2 inches to 1 foot thick.
D. Boulder-clay, more stony at top, up to 12 feet thick.
E. Sandy and clayey angular gravel, occasionally bedded with some lenses of pure sand; rests on irregular surface of Boulder-clay. 1½ to 4 feet thick.
F. Surface soil.

On the north side of the headland the present cliff face is chiefly of solid rock and is much obscured by vegetation. Coarse angular rubble-drift may be seen in places near the top of the cliffs resting on the Ordovician rocks, and the subsoil frequently contains a layer of cockle-shells. The Boulder-clay reappears in about 300 yards at the top of the cliff, and rapidly increases in thickness northwards by descending to the present beach-level or nearly so, being as much as 20 feet thick and forming practically the entire face of the cliff all the way to Raheen Stream. A layer of sandy clay or marl containing few or no stones overlies it with a thickness of 1–1½ feet, as on the south side of the headland. At the spot where the fossiliferous Raheen Shales are exposed on the foreshore the recent removal of shingle and slipped material from the base of the cliffs which has been obscured in former years has exposed in section the pre-glacial platform and the deposits immediately overlying it. This platform is cut across the edges of the steeply-inclined Ordovician beds elsewhere described, and its surface forms a fairly regular and horizontal line in the face of the cliff about 3 feet above its base. The height of this rock-platform above the present high-water mark seems only 3–4 feet, and its upper 1–1½ feet is somewhat shattered and rotten, though the line of demarcation from the drift deposits is always sharp and clear. In one place a small stream running down to the present seashore has cut a narrow gully through the Boulder-clay, but its vertical corrosion has been stopped by the pre-glacial platform so that it falls over its eroded edge in the cliff in a small waterfall.

There is a layer of angular débris here and there resting on the platform, composed of small angular fragments of the underlying rock, but in several places bedded sandy fine shingle or sand with larger well-rolled beach pebbles in it is found to a thickness of 2 feet. The Boulder-clay rests directly on it, and contains near its base a few large rounded or subangular boulders (some as much as 3 feet in diameter) of the local Old Red Sandstone or local igneous rocks, but no true Lower Head. Probably the absence of the Lower Head may be explained by the fact that the pre-glacial cliff lies now some distance inland and that the Head did not extend far out from its foot, while here we are dealing with the more seaward portion of the platform. In most cases the Boulder-clay rests here immediately on the solid rock without any intervening deposit. The activity of post-glacial coastal erosion at this point and the non-resistant character of the rocks are illustrated by the solid rock of the old pre-glacial platform being cut back as rapidly as the drift cliffs, so that they are both exposed in section in one and the same vertical face. But where the rocks are of a tougher nature traces of the old platform extend over the foreshore as irregular ridges and reefs of rock.

On the north side of Raheen stream, which has cut down right through the platform to the present sea-level, there is an excellent exposure of the platform, for it forms a flat-topped shelf several yards wide jutting out on the foreshore at the base of the present cliffs of drift, and has not been so much eroded or dissected as a little further south. It is here cut across the edges of the nearly vertical slates and flags, almost at right angles to their strike, and its level surface has 2–3 feet of coarse angular débris (Lower Head) of the same rocks resting upon it and capped by the usual Boulder-clay. About half-way between the gap at Raheen Bridge and the gully of Carey's Stream we find a true beach deposit on the platform in the shape of well-rounded pebbles cemented together in a little coarse sand. The Boulder-clay reposing directly on these deposits is of a reddish colour and marly character, and contains few stones; it averages 2–3 feet in thickness, but generally it passes up into the normal type of Boulder-clay except from the spot where this beach deposit occurs.

At this point the reddish clay is succeeded by a sharply marked off band of greyish clay 1½–2 feet thick, characterised by containing numerous angular fragments of black or greenish slate, mostly small, but scarcely any fragments of Old Red Sandstone. Northwards this slaty deposit assumes a definitely bedded character with a sandy or marly matrix, at the same time increasing in thickness till about half-way between Raheen and the Cable Station it is quite 5 feet thick, with the upper part composed of rather large angular fragments 4–8 inches long of banded purple and green slates lying flat and horizontal with little finer matrix between them, the lower portion, however, still consisting of smaller and more scattered chips of slate in bedded sandy clay. Boulder-clay, 1–2 feet thick, of somewhat variable character, lies beneath it, resting directly on the platform without the intervention of any true 'head,' but here and there a thin black layer, 2–3 inches thick, full of small rounded pebbles and angular chips of slate cemented together, adheres to the platform, and seems to be a local modification of Messrs. Wright & Muff's 'ferricrete.' The bedded slaty deposit thins out before we reach the Cable Station, and the Boulder-clay forms the whole cliff 30–40 feet high. Thin bands of reddish or ochreous clay 2–4 inches thick can here and there be distinguished near the base of the cliffs in the Boulder-clay, but only persist for a few yards. The rubble drift on the top of the cliffs is usually thin, but rests on a somewhat irregular surface of Boulder-clay. Landslips and vegetation much obscure the section beyond the Cable Station, but the cliffs steadily decrease in height, owing to the reduction in thickness of the Boulder-clay, and below Crooke Chapel they are only 6–8 feet high. About 100 yards north of Crooke the solid rock of the old platform appears on the beach close under the low cliffs, being disclosed in patches between the shingle; it consists of greenish-grey and sea-green shales, slates and flags in thin alternating layers; soft purple shales and fine-grained purple flags are intercalated a little further north in beds ½ inch to 3 inches thick, alternating with the greenish beds. These all dip regularly at 80° in a general northerly direction or are vertical. The Boulder-clay apparently rests directly on this platform, but the latter soon is lost to sight, and our interest is concentrated on the cliffs, which begin to increase in height, and in which the Boulder-clay, capped by about 2 feet of rubble drift and subsoil, is remarkable for the large number of huge boulders imbedded in it. Many of these are of non-local rocks (granites, quartzites, etc.), and these are more or less rounded and reach a size of as much as 2½–4 feet in length. The masses of the Old Red Sandstone breccia are angular and even larger in size.

A most varied series of the non-local rocks can be easily collected out of the Boulder-clay here, and the beach is strewn with similar boulders of all sizes derived from the cliffs. About nine-tenths of the larger blocks are of the local Old Red Sandstone beds, but examples of the Ordovician rocks, igneous and sedimentary, of co. Waterford itself (i e. of the country to the west) are remarkably rare.

A few blocks of the felsites and other igneous rocks (especially the nodular perlitic felsite of Raheen gap) have been drifted up-stream from Newtown Head, but only occur on the beach and not in the

Boulder-clay; moreover, their unworn condition generally enables them to be easily recognised.

Of the non-local sedimentary rocks the commonest are white, grey, or yellowish fine-grained quartzites occurring as well-rolled and rounded boulders up to a foot in diameter. Some coarser-grained quartzose grits may also be occasionally found.

Blocks of Carboniferous Limestone in a well-rounded condition are frequent; they are usually of a dark bituminous variety, and often contain fossils (*Lithostrotion*, *Productus*, etc.), and some of these boulders measure two feet in length. A pale-grey crinoidal limestone from the Carboniferous Series is sometimes found. Pieces of chert are rare, and no flints such as Messrs. Wright and Muff have described on the Wexford coast have been observed.

Of the non-local igneous rocks a rather coarse-grained but non-porphyritic grey granite occurs rather plentifully in much rounded boulders and subangular blocks of all sizes, and it seems identical with the Mt. Leinster granite. Boulders of pink granite of two or three varieties are much less common. A greyish granophyre or micro-granite is as abundant as the grey granite; and likewise blocks of a diorite, several gabbros, coarse porphyritic diabases, aplites, quartzose schists, schistose felsites, gneisses, augen-gneisses, vein-quartz, vein-breccias, etc., may be extracted out of the cliffs in a more or less worn and rounded condition.

The derivation of this varied assortment of non-local rocks from the area to the north (Wexford, Kilkenny, Wicklow, etc.) cannot be doubted, and the Boulder-clay which contains them must be regarded as the deposit of the inland ice[1] and not of that from the west or the Irish Sea.

At a point about 500 yards south of Passage East, where the cliffs of drift reach a height of 30–40 feet, we notice coming in at their base beneath the Boulder-clay a more or less bedded deposit of angular slabs, flakes, and chips, of the slates, shales, and flags of the pre-glacial platform which was exposed on the foreshore nearer Crooke. The fragments are sorted into fairly uniform sizes, 2–4 inches in length, and lie flat and closely packed without much intervening finer material. The deposit rapidly increases in thickness as we follow it northwards in the cliffs. The base of it becomes much coarser, the fragments being 1 to 2 feet long, but still lying flat and horizontal, and all consisting of ragged angular slabs of the slates, etc. A few small rolled pebbles of Old Red Sandstone may be found in this Lower Head, but they are very rare. The upper part of the deposit, on the other hand, becomes composed of minute flakes and chips of soft Old Red purplish shales aggregated into a loose crumbling and unconsolidated mass of material, without any appearance of bedding and extremely apt to slip down on account of its incoherent character. Near the base of the coarse slaty head at the foot of the cliffs there is a layer, 4 inches to 6 inches thick, of similar angular fragments cemented together into 'ferricrete' by infiltrating water with iron oxides, and it can be traced horizontally for over 50 yards. An interesting section is seen here in the cliffs where a landslip has recently occurred. The coarse angular head of slate fragments, 4–5 feet thick, lies at the base; it passes up gradually by diminution in the size of the rubble into the fine crumbling incoherent deposit of flakes of shale, which is 12–15 feet thick; above this comes 6 feet of Boulder-clay, containing many large boulders; and resting on this are 3½–6 feet of false-bedded gravel, pebbly sand, and lenses of pure sand. This deposit above the Boulder-clay was evidently laid down by water; the pebbles are small and well rolled, and large pebbles are very rare. Subsoil and soil, to a thickness of 1–1½ feet, lie on the top of all.

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[1] Wright & Muff, Scient. Proc. Roy. Dublin Soc., vol. x, part 2 (1904), p. 269.

The basement bed of coarse head contains more and more frequent fragments of the Old Red Sandstone rocks as we approach Passage; the slates become an insignificant element and ultimately disappear, the head then consisting of small angular and subangular fragments of the local Old Red beds, mostly 1–4 inches in size, with very little clayey matrix and with occasional huge ragged blocks of the Old Red breccia. These masses become more common and the head still much coarser till the finer material practically disappears, and great irregular jagged blocks of the breccia, some 5 feet in length, are jumbled together into a deposit of 8–9 feet thick, on which the Boulder-clay reposes. The foreshore is strewn with big boulders and angular masses derived from the cliffs. The platform of greenish and purple slates, etc., on which the drift rests is visible here and there on the beach, but not above the present high-water mark.

The actual pre-glacial cliff is not exposed, and the section ends abruptly with the termination of the drift cliff and with the beginning of the sea wall and embankment along the south side of the low flat area on which Passage village is chiefly built at the bend of the river.

The hill which rises 250 feet above the village is mainly composed of the coarse Old Red breccia, which enters so largely into the composition of the Lower Head at the northern end of the section, and the older slates, etc., on which the Old Red rests with such a striking unconformity form the lowest slopes and base of the hill, and have furnished the material for the other type of head.

V.—THE INCLINATION OF OVERFOLDS IN RELATION TO THE LARGER FOLDS IN WHICH THEY ARE CONTAINED.

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WHILE spending a few days recently examining the sections on the North Devon coast, with a view to obtaining a clearer conception of the tectonic structure of that region, I was deeply impressed by the great number of minor overfolds and with the great uncertainty in the relations of the various beds thereby brought about. In many cases where the dip appears to be constantly to the south, through a considerable thickness of strata, closer examination shows repeated isoclinal folds. The western face of Little Hangman Hill at Combe Martin exhibits such a condition very well. Throughout the whole coast which I examined, from Combe Martin to the southernmost part of Bideford Bay, the axes of the minor folds are inclined to the north in this way, so as to frequently produce the appearance of steady southern dip and greatly to increase the apparent thickness of the strata. In speculating as to the possible cause of the constant direction in which the axes of these folds are inclined, an explanation occurred to me which I believe to be the correct one, and which may be applied generally to a large number of cases. As I have been unable to find it in the works I have been able to consult, it may be desirable to publish it, since it may aid considerably the elucidation of the true structure and history of complicated districts.

The one feature in the structure of Devon which admits of no dispute is the broad syncline which comprises the whole county. On this broad fold those previously referred to are superadded, and from the parallelism of the two, and the fact that they were both formed after the Culm and before the Permian, it is almost certain that their formation proceeded *pari passu*. How, then, would the form of the minor folds be affected by the fact that the whole area was at the same time becoming a syncline? It is obvious that in a synclinal fold the upper beds tend to be compressed, the lower ones to be extended. Both of these effects are resisted, and the result is a sliding of the beds relatively to one another on the sides of the fold. This may be illustrated admirably by an experiment described by Mellard Reade in his "Origin of Mountain Ranges" (p. 210 and pl. xlii). A number of strips of paper are laid horizontally, and their edges marked across with vertical lines thus:—

FIG. 1.—Edge-view of pile of paper strips, with lines drawn across at right angles to the plane of the papers. (After Mellard Reade.)

If the paper is now forced into folds, the displacement of the various layers relatively to one another is shown by the fact that the vertical lines are no longer vertical to the surface of the paper, thus:—

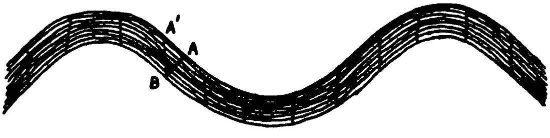

FIG. 2.—The same papers folded, showing displacement of lines. (Modified after Mellard Reade.)

The line starting at B, for example, instead of passing at right angles to the plane of the strips towards A, is displaced to A′. Now, if these vertical lines be assumed to represent the axial planes of minor folds, it is clear that those folds will become asymmetrical, their crests being forced outwards from the centre of the syncline. In a shallow syncline the displacement of these axes would only be slight, but, however slight, it would still exist, and would determine that the folds would be asymmetrical, with their steep sides facing away from the main synclinal axis, on either side, as indicated in the subjoined diagram.[1]

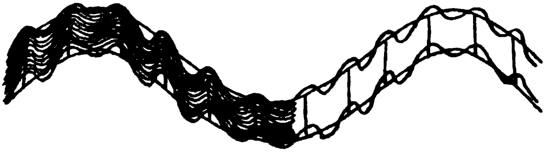

FIG. 3.—Showing the distortion of minor folds by the relative displacement of the layers in the larger one.

Let us now assume the lateral compression of the whole area to continue. What will be the result? Either the general syncline may become deeper, or the minor folds may be accentuated. But, since the extent to which a great fold can be raised or depressed is limited, the latter result will sooner or later occur, and as the minor folds are accentuated they will become overfolds, tending more and more to be isoclinal as they are further compressed. It is important to notice that *the limbs of such isoclinal folds will dip towards the axis of the major syncline, on either side*. Here, I believe, we have the true explanation of the character of the folds seen so admirably on the North Devon coast.

It is scarcely necessary to add that what has just been said of minor folds on synclines will apply equally, with suitable modifications, to minor folds on anticlines. In the latter case there will tend to be produced more or less isoclinal folds with limbs dipping away from the main anticlinal axis. Hence we may conclude as an important general rule that *the direction of dip of the limbs of a series of isoclinal folds indicates the direction of dip of the side of a larger fold on which they have been produced*. By this means, the former existence of a great fold may be inferred when the structure of a district has become so complicated that direct evidence of it is obscured or lost.

For example, if in a great syncline a series of minor overfolds are produced on either side as here described, and the crushing still continues, it is evident that the sides of the syncline will gradually be pushed in under the central portion, and fan-structure will be the result. And thus it would seem highly probable that areas presenting fan-structure, notwithstanding the fact that they present the general features of an anticline, and have, indeed, been aptly described as anticlinorums, have originated by the modification of great synclines. As my friend, Mr. D. M. S. Watson, suggested to me, an analogous process may help in some degree to explain why hills have so frequently a synclinal structure.

Further, it needs little consideration to show that the direction of overthrusts will be governed by the same rule that holds for overfolds, since the latter pass into the former. Hence, if a pair of overthrusts dip towards one another, it is highly probable that the area they enclose was primarily a syncline, or, on the other hand, if they dip away from one another, an anticline. Thus, from the direction of the two great series of thrust-planes which form the north-western and south-eastern boundaries of the Grampians it seems probable that that region began its tectonic history as a syncline, while the central lowlands, on the other hand, would seem to have been a corresponding anticline.

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[1] This modification of the minor folds may be beautifully demonstrated by taking a pile of sheets of paper laid flat, drawing symmetrical curves on the edges, and then folding the paper. If the paper is folded sufficiently, beautiful isoclinal curves may be produced.

It will be observed that the Central Lowlands now form a broad syncline. But that is just what should be expected. From a consideration of what has already been said it should be clear that the original folds tend to become virtually reversed, the axes of the synclines raised, and the summits of the anticlines depressed.

No doubt, from the premises that the form of a minor fold is influenced by the side-shift of superposed beds caused by the formation of a larger fold in which it is contained, many more interesting deductions might be drawn, but enough has, I think, been said to illustrate the nature and general effect of that influence. That the relation here stated is the only cause of the deformation of minor folds I would not wish in any way to suggest. The series of strains and stresses set up in the terrestrial crust must be more complex than we can ever hope to completely disentangle. But I do maintain that we have here a distinct set of effects which can be separately recognised and traced to a definite cause. That other influences must give rise to irregularities is inevitable. Yet I think an appeal to the rocks shows that there is still, in many cases at least, a distinctly recognisable residue of effects which may be traced to this one cause, by the observation and consideration of which much help may be derived in the elucidation of the tectonic history of complex districts.

NOTICES OF MEMOIRS.

I.—Index Generum et Specierum Animalium.[1]

THE indexing of the literature for the second portion of this Index (1801–1850) has steadily progressed. Among the works included are:—Archiv für Bergbau, etc., 43 vols.; Archiv für die gesammte Naturlehre, 27 vols.; Archiv für Naturgeschichte, 16 vols.; Athenæum, 23 vols.; Basel, Naturforschende Gesellschaft, 8 vols.; Batavia, Batav. Genootsch., 16 vols.; Beiträge zur Petrefactenkunde (Muensters); Berlin, Gesellschaft naturforschende Freunde; Berlin, Bericht und

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[1] Report of the Committee, consisting of Dr. Henry Woodward (Chairman), Dr. F. A. Bather (Secretary), Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Dr. W. E. Hoyle, Hon. Walter Rothschild, and Lord Walsingham. By C. Davies Sherborn, F.G.S., F.Z.S. Read before Section D (Zoology), British Association, Leicester, 1907.

Abhandlung k. pr. Akad. Wiss., 50 vols.; as also the writings of Audouin, Audebert, Audubon, Audinet, and Bechstein, a list which might be considerably extended.

The accumulated results of three years recording have now all been arranged and sorted under their respective genera, and, therefore, one set of entries is now available for reference by monographers so far as recording has proceeded. The duplicate set of entries has been partially arranged and further accommodation has been provided by the kindness of Dr. Smith Woodward in the Geological Department of the British Museum (Natural History), which has greatly relieved the pressure arising from the steady growth of material.

II.—INVESTIGATION OF THE PRE-DEVONIAN BEDS OF THE MENDIPS.[1]

THE principal objects which the Committee had in view were two in number—(1) To obtain a further series of fossils from the newly discovered Silurian beds of the area. (2) To investigate the distribution in the field of a peculiar coarse ashy conglomerate, and to ascertain its relations to the other deposits of the neighbourhood. With these ends in view a series of seven trenches was dug, and the information obtained from them was incorporated in a paper by the Secretary.[2]

The most easterly of these trenches was dug in a field about 300 yards S.S.W. of Tadhill Farm. It was carried to a depth of about six feet, and after passing through some 18 inches of surface material, entered a deposit consisting mainly of very fine yellow and brown ash, with subordinate bands of coarse ash. Many of the bands were crowded with fossils, which were identified by Mr. F. R. C. Reed.[3] The series of fossils, though undoubtedly Silurian, and, in Mr. Reed's opinion, probably of Upper Llandovery age, was insufficient to determine the point with certainty.

A second trench dug at a point about 100 yards to the north of that in the fossiliferous tuff proved to be in trap (pyroxene andesite).

The remaining five trenches were all dug in the neighbourhood of the rifle butts on Beacon Hill (about a quarter of a mile to the north of Beacon Farm), where the coarse ashy conglomerate was originally exposed in a target pit. Four trenches dug at different points in the neighbourhood of the rifle butts showed that the coarse ashy conglomerate here probably occupies the whole area between the northern and southern outcrops of the Old Red Sandstone. A fifth trench was opened on the slope of the hill to the north of the rifle butts, but after passing through nine feet of Old Red Sandstone this trench was abandoned.

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[1] Report of the Committee, consisting of Mr. H. B. Woodward (Chairman), Professor C. Lloyd Morgan, the Rev. H. H. Winwood, and Professor S. H. Reynolds (Secretary). (Drawn up by the Secretary.) Read before Section C (Geology), British Association, Leicester, 1907.

[2] Published in the Quart. Journ. Geol. Soc., vol. lxiii (1907), pp. 217–238.

[3] See list, op. cit., pp. 226–227.

III.—Desert Conditions and the Origin of the British Trias.[1]

By J. Lomas, A.R.C.S., F.G.S.

It is now generally conceded that the Triassic rocks of our Islands are not of marine origin, but true continental deposits, and the view has of late gathered strength that the climate was arid when they were laid down. We can only hope to reach a safe conclusion by a critical examination of existing deserts. Let us confine ourselves to a consideration of the activities now at work in some typical sandy deserts, such as we suppose to have existed in Triassic times.

Sandy Deserts.

Rainfall.—As a rule sandy deserts are characterised by a low rainfall, and their distribution is in general either on the leeward sides of mountain ranges or in valleys and plateaux between such ranges. In Northern Egypt the precipitation ranges from 0·27 inch at Cairo, to 1·1 in. at Suez, 2·1 in. at Ismailia, 3·4 in. at Port Said, and 8·1 in. at Alexandria. In South California and West Arizona certain regions have a mean annual rainfall of less than 2 inches. In the Karoo the precipitation varies from 8·65 inches at Steotleville to 18·76 in. at Graaff-Reinet (Buchan). In the Kalahari desert from 3·79 in. at Pella to 41·10 in. at Pilgrims Rest. On the west coast of Africa from 2·11 in. at Port Nolloth to 8·37 in. at Clan William.

Examples need not be multiplied; those quoted are sufficient to show that the amount is generally small and varies very considerably in different places. An equally important consideration is the *time* during which rain falls. If the precipitation is confined to one season and for the rest of the year there is little or no rain, desert conditions may exist, although the annual rainfall is comparatively large. During the wet season the ground may be well watered, and streams of torrential size flow over the country, but the water is soon lost by percolation or evaporation and none is stored up to water the land in time of drought.

Vegetation is either very scant or absent, and the lack of vegetable mould diminishes the power of the soil to retain moisture. Professor N. S. Shaler (U.S. Geol. Surv. 12th Report) points out too that the absence of vegetable mould commonly causes the soil to present a dense baked surface which sheds rain like a roof.

Streams of Desert Regions.—In South Africa during the dry season we often come across deep watercourses excavated during the time of the seasonal rains but now perfectly dry. Their beds are covered with well-rounded boulders of such a size as to indicate that torrents must have flowed down the courses in order to move them. Towards the mountains the banks become steeper and loftier, while in the direction of the plain the valley merges into the general outlines of the veldt, and at the junction it is marked by a spread of pebbles. In the Libyan and Algerian deserts similar watercourses are found in the neighbourhood of their enclosing mountains. They are liable to floods of so sudden appearance and of such torrential violence that people engaged in gathering firewood, brought down by former floods, are sometimes overtaken and have no chance of escape. At one time the bed may be perfectly dry and a moment later it is filled with a rapid stream hundreds of feet wide. In India these sudden floods are sometimes miles in width; they have no defined channel, but flow like a sheet over the land.

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[1] Proc. Liverpool Geol. Soc., vol. x, pt. 3, 1907, pp. 172–180; slightly abridged.

It is worth while at this stage to picture what kinds of deposits are being formed under the conditions just described. While the main portion will be composed of sand there will be included at various horizons patches of gravel, lenticular in shape and of limited extent. I have seen sections through such deposits in a dry donga near Tintas Kopje in the Vryheid district, and again in railway cuttings when traversing the Eastern desert of Egypt between Ismailia and Cairo. The pebble bands varied from a few inches to 4 or 5 feet in thickness, and in my notebook is an entry "exactly like our Bunter." However, we shall return to that later. I only wish at present to record the impression made on me at the time.

What becomes of the water?—The water flowing over the sand may be disposed of in three ways. (1) It may percolate under the surface; (2) it may be evaporated; (3) it may lodge in pools or lakes in places which are below the general level of the country.

(1) *Percolation.*—It has been known for a long time that under the dry baked sands of the desert there commonly exists a great store of water, which only needs to be tapped in order to be available for use. In the Sahara artesian wells were sunk by the Greeks and Romans. In Algeria a class of men called Meallem were formerly employed as water-finders, and another class—the R'tassin—were engaged in the construction and cleaning out of wells. Their methods were primitive and involved great dangers. Since the French occupation more scientific appliances have been introduced, and the fringe of fertile soil on the margin of the great Sahara is gradually being extended southwards. In sinking the dry sand is penetrated until an impermeable clay or pan is reached. On piercing this the water rises, sometimes with sufficient force to reach the surface. The depth of the impermeable layer varies from a few feet to hundreds of feet, and striking differences of level may be encountered within a short distance.

The condition of the water below the impervious bands must necessarily be largely a matter of inference. We naturally want to know whether it is stagnant or flowing, and whether it is carrying substances in solution and depositing these round the sand grains and thus cementing them into compact rock. If the water is flowing it must trend towards an outflow, and if this is restricted in area there must be definite lines along which the water runs. The stream lines will, under these circumstances, be convergent towards the outfall, and the water outside the cone of flowing water may be stagnant.

That subterranean streams of fresh water do flow into the Red Sea from the desert is certain, and opposite their mouths the coral growth round the coast is interrupted. Some of these streams have been traced underground for great distances almost to the base of the

Abyssinian mountains. The wells in the oases, too, must be fed from the same source.

Similar lines of flow of percolating water can be traced in our local Triassic rocks. Sometimes they show themselves by a deeper staining, and in extreme cases the grains of sand have become so heavily charged with interstitial matter that they have formed pipes, the interior of which is dark brown or even black, while the sand surrounding is almost white.

(2) *Evaporation.*—Another way in which the water flowing from the high grounds is disposed of is by evaporation. The amount of evaporation is largely dependent on the relative humidity of the air. Over the oceans the air may be approximately saturated, but in deserts the amount is commonly as low as 20 per cent. of the total capacity of the air to hold moisture. At Assuan it is 38 per cent. for the year, varying from 29 per cent. in Summer to 51 per cent. in Winter. At Wadi Halfa the average for the year is 32 per cent.

When the air is not saturated, there is a constant exchange of water from the land to the atmosphere, and this results in evaporation at the surface and a creep of water from below owing to capillary action. Mineral substances contained in solution are disengaged from the water on evaporation at the surface, and the soils in course of time become charged with saline matter. In this way the 'sour' or 'alkaline' soils have their origin.

The nature of the encrustation will, of course, depend on the composition and the amount of salts which the water holds in solution, and these again are dependent on the nature of the rocks over which the water passes. Potash and soda salts are common encrustations in some regions, and they are often associated with the carbonates and sulphates of the alkaline earths. The former may be redissolved and partly removed in the rainy season, but the salts of the alkaline earths will be effected only to a very slight extent and will tend to accumulate. A very instructive example of this occurs in the dry donga near Vryheid mentioned above. Near the surface the sands are coated with carbonate of lime. Sometimes there appear embedded in the sand roundish balls, ranging from the size of a marble to that of a man's head. In other places limestone of a compact texture and not enclosing sand forms a continuous layer on the surface of the ground.

At Croft, near Leicester, a calcareous crust exactly resembling that found in deserts occurs on the surface of the underlying igneous rock, and the covering Keuper marls are strongly impregnated with lime salts.

(3) *Desert Pools and Lakes.* — Looking across a vast expanse of desert the monotony of the scene tends to dwarf the sense of vertical height. With no outstanding features to rivet the attention of the eye the rolling dunes or naked rock give the impression of a level landscape. As a matter of fact the desert has its hills and its hollows, its crags and its ravines. In some of these hollows, enclosed in a network of dunes or in rocky basins, water tends to accumulate and form pools or lakes. They may be fed by rain, by water percolating through the surface sand, or by streams flowing from the hills.

Often they have no outlet, and then the water can only be lost by evaporation. They are full to overflowing when the seasonal rains fall, but during the long drought the waters gradually diminish, and in many instances totally disappear.

The water which finds its way into these pools or lakes brings with it matter in suspension and in solution. The former settles at the bottom as a fine mud. The mud, on drying, shrinks and forms the triradiate cracks characteristic of contracting sheets; it receives the imprints of animals' feet when they come to drink, and the impressions of rain when it falls.

The mud from the margin of a partially dried up vley at Riverton in South Africa shows all these features, and in addition it contains vast quantities of the carapaces of *Estheria*, a tiny Crustacean which has its proper habitat in such surroundings.[1]

The matter brought into the pools in solution will tend to concentrate as the water diminishes, and on complete drying, deposits of salt, gypsum and other salts will be left behind.

The salinity of the water will vary with the season. Thus, pools in the Rajputana desert in India are fresh for two or three months in the year. One constantly comes across contradictory statements in reading books of travel as to the salinity or otherwise of certain lakes. The observations may be right in each case if the travellers visited the lakes at different seasons of the year.

(*To be concluded in our next Number.*)

REVIEWS.

MEMOIRS OF THE GEOLOGICAL SURVEY.

I.—THE GEOLOGY OF THE SOUTH WALES COALFIELD. Part VII: THE COUNTRY AROUND AMMANFORD. By Dr. A. STRAHAN, F.R.S., T. C. CANTRILL, B.Sc., E. E. L. DIXON, B.Sc., and H. H. THOMAS, B.Sc. Text, pp. 246, with 12 illustrations, price 2*s*. 6*d*. Colour-printed maps, Sheet 230, Drift and Solid, 1*s*. 6*d*. each.

Part VIII: THE COUNTRY AROUND SWANSEA. By Dr. A. STRAHAN, with parts by R. H. TIDDEMAN, M.A., Dr. W. GIBSON, and E. E. L. DIXON, B.Sc. Text, pp. 170, with 4 illustrations and 5 plates, price 2*s*. 6*d*. Colour-printed maps, Sheet 247, Drift and Solid, 1*s*. 6*d*. each.

WITH the publication of these Memoirs and that of Part IX (West Gower) already noticed in the GEOLOGICAL MAGAZINE (August, 1907, p. 371) we witness the completion of the survey of the main portions of the great South Wales Coalfield, and Dr. Strahan is to be congratulated on the progress thus made in a task in which he has taken the prominent part and has personally superintended.

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[1] "Habitat of *Estheria*": Trias Report, British Association, 1905; and Monog. Pal. Soc., 1862, p. 57.

The area of Coal-measures included in the maps before us and described in these Memoirs was originally surveyed by Sir William E. Logan; and the results of his labours were generously placed at the service of De la Beche, who surveyed portions of the Lower Carboniferous rocks and Old Red Sandstone. Aid was also received from John Phillips among the Lower Palæozoic rocks.

The results of the recent survey on the six-inch scale show a great advance in methods and details, in the determination of the numerous lines of fault, and in the mapping of the superficial deposits. These advances are shown perhaps more conspicuously in the Ammanford area, where Cambrian (Tremadoc) rocks have been recognized, while no less than eight subdivisions, together with limestone bands, are represented in the Ordovician rocks, five subdivisions are shown in the Silurian, six in the Old Red Sandstone, and many in the Carboniferous rocks. In this great series of formations it is estimated that the thickness of strata amounts to nearly five miles. We have been a little puzzled to find Ammanford on the map, but have succeeded in doing so with the aid of a gazetteer wherein Ammanford is mentioned as a hamlet with "coal-mines, also paint and oilworks." As a matter of fact, there is no town of note in the area, and the population is somewhat scattered along the principal valleys, such as the Tawe between Ystradgynlais and Pontardawe.

Mr. Cantrill and Mr. Thomas have largely added to our knowledge of the stratigraphy and palæontology of the Lower Palæozoic rocks. The Llandeilo Series is described with the spelling Llandilo "for the sake of conformity with the New Series Ordnance Maps," a change which hardly makes for uniformity, as it is inconsistent with the generally accepted spelling of geologists.

A table and local lists of Lower Palæozoic fossils are given, and a method has been devised whereby the precise locality, the collector, and the destination of every specimen have been recorded. It must be admitted that these important particulars are not of much value in the memoir, except when it is used in the Museum at Jermyn Street, where are preserved the specimens and also the six-inch maps on which the localities are indicated.

Interesting accounts are given of the changes in the lithology of the Old Red Sandstone and of the overstep of its basal portions across the Silurian outcrop. The dominant features in the region are great plateaus formed by the Millstone Grit, which rises in Black Mountain to a height of 2,076 feet, and by the Pennant Grit, which locally reaches a height of 1,371 feet. Reference is made to the 'plastic clay' in the Millstone Grit, a fine mealy sand due to the decomposition of chert, which was formed from very fine siliceous sediment, partly of clastic quartz grains and partly of organic material. Full particulars relating to the Coal-measures are given by Dr. Strahan. The lower seams of coal, traced along the 'North Crop,' from the Tawe valley through Ammanford and the Llandybie district to the Gwendraeth valley, are all anthracitic; whereas in the 'South Crop' the lower seams "are all bituminous, and there is little doubt that in the intervening ground they pass through the intermediate stage of steam-coal."

In the Swansea area the Coal-measures attain a greater thickness than is at present known in any other part of the coalfield, about 7,000 feet. In this great series is included about 1,050 feet of the highest measures. Seams are worked in all three divisions of the series.

A notable discovery by Logan was that of pebbles of coal in the Pennant Grit near Swansea. We fail to find any particular reference to this, although incidentally the occurrence of pebbles of coal is mentioned.

In the Swansea map are included the eastern portions of the picturesque region of Gower, where Silurian rocks were discovered by Mr. Tiddeman. There are many other features of great interest in that promontory, in the lithological characters of the Lower Carboniferous rocks, and in the disturbances to which they have been subjected. The dolomitisation of the limestone, to which special attention has been given by Dr. Pollard and Mr. Dixon, is regarded as for the most part contemporaneous, the alteration having taken place so shortly after deposition that the magnesian salts were probably derived from the Carboniferous sea. Again, the recognition of radiolarian cherts in the Upper Limestone Shales confirms De la Beche's correlation of the strata with the Coddon Hill Beds of North Devon.

The Glacial Drifts in the areas of Ammanford and Swansea indicate the former great development of ice in regions further north, whence there was a southerly movement, the ice overriding and glaciating all except the higher hills. Important, too, is the evidence gathered by Mr. Tiddeman that this glaciation is later than the Raised Beach of Gower and the Cave accumulations with Pleistocene mammalia.

II.—THE GEOLOGY OF THE LEICESTERSHIRE AND SOUTH DERBYSHIRE COALFIELD. By C. FOX-STRANGWAYS, F.G.S.; with Palæontological Notes and List of Fossils by A. R. HORWOOD. 8vo; pp. 373, with colour-printed geological map, 6 plates, and 12 text-figures. Cloth; price 6*s*.

IN 1860 a concise memoir by Edward Hull on "The Geology of the Leicestershire Coalfield and of the Country around Ashby-de-la-Zouch" was issued by the Geological Survey. It occupied 70 pages of print, was accompanied by a neatly coloured geological map engraved by Lowry, and was sold at the price of 3*s*. It was a handy memoir, well adapted for the pocket of anyone who was making a personal study of the area. Now after a lapse of nearly fifty years the results of a far more detailed survey, carried out on the six-inch scale entirely by Mr. Fox-Strangways, have been published in the memoir before us. Although the paper and printing of the present work do not equal that of the former one (see, for instance, the figure of Outcrop of the four-foot coal at Blackfordby), yet when we compare the bulk of this work with its predecessor—the number of printed pages, including much tabular matter, the large folding plates of sections, and the cloth case—a comparison of the respective prices is wholly in favour of the new volume.

It is pleasant to read that a cordial acknowledgment of the services rendered by the Rev. W. H. Coleman (given in the earlier volume) is also made in the present work, in which, indeed, there is a full bibliography drawn up with characteristic precision by Mr. Fox-Strangways. Everywhere throughout this volume we find a careful and methodical statement of the facts, with due acknowledgment of previous workers.

The author gives an interesting history of the development of the coalfield, from the earliest mention of coal-working in the district—the reign of King John in 1204—to the present-day workings. Mention is also made of the clay that has been extensively used in the manufacture of sanitary earthenware. Not the least important part from a practical point of view is the record of colliery borings and pit sections, which occupies nearly 200 pages. A useful chapter is also devoted to a consideration of the probable extension of the coalfield beyond the present workings. While, however, the memoir is mainly occupied with a detailed description of the Coal-measures, there are appropriate accounts of the older and newer formations, of the Pre-Cambrian, Triassic, Pleistocene, and Recent deposits.

Palæontological information is by no means neglected. There is a list of fossils from the Carboniferous Limestone based largely on a collection made by Mr. H. Vassall; while an important section on the palæontology of the Coal-measures has been contributed by Mr. A. R. Horwood, a zealous worker at Leicester.

In this full and practical account of the geology of an important coalfield are embodied the results of the final official field-work of the author, who has since retired from the public service.

III.—THE GEOLOGY OF THE LANDS END DISTRICT. By CLEMENT REID, F.R.S., and J. S. FLETT, M.A., D.Sc.; with contributions by B. S. N. WILKINSON, E. E. L. DIXON, B.Sc., and W. POLLARD, M.A., D.Sc. Mining appendix by D. A. MACALISTER, A.R.S.M. pp. 158, with 6 plates and 35 text-illustrations. Price 3*s.* 6*d.*

ATTENTION was drawn in the April number of the GEOLOGICAL MAGAZINE to the memoir on "The Geology of Falmouth and Truro and of the Mining District of Camborne and Redruth." We are now able to introduce to notice the description of the adjacent area on the west, which includes the mining regions of St. Just, St. Ives, and Gwinear. The slaty rocks of this area are grouped as Lower Palæozoic, in accordance with Mr. J. B. Hill's grouping of the Mylor, Falmouth, and Portscatho Series, which may be Ordovician or of earlier date. More interest attaches to the physical structure of the district, to the greenstone and granite intrusions, to the effects of metamorphism, and to the genesis of the mineral veins. The sills of greenstone produce great alteration, which, however, extends but a short distance, in the adjoining killas; and rocks thus changed appear to have been little influenced by the subsequent granite intrusion. The granite is described as occurring in great sheets or laccolites, and to form an undulating floor over the whole of the region described, and at no great depth (as mentioned on p. 3), or at depths of 4,000 to 5,000 feet (as noted on p. 8). This floor rises in domes and bosses, and its proximity to the surface is indicated by inliers of altered killas or of the metamorphic aureole. The coarse and the somewhat later fine-grained granite are duly described; and the effects of fluoric and boric vapours that emanated from the granite prior to its complete cooling and consolidation are pointed out. The 'schorl rock' and the variety known as luxullianite have been produced by these pneumatolytic processes; while most of the mineral lodes which occur in the metamorphic aureole surrounding the granite are attributed to like agencies. In the luminous chapters on these subjects, written conjointly by Mr. Reid and Dr. Flett, there is much that advances one's knowledge of these interesting phenomena.

An account is given of the possible preservation of Eocene gravel under the sea not far from St. Michael's Mount, and attention is directed to the phonolite of the Wolf Rock which is depicted in an inset on the colour-printed map, while its actual position is indicated in a small map on page 2. This volcanic rock may be of Tertiary age, but we are at a loss to understand why "no special description of the phonolite of the Wolf Rock is needed here." Being regarded as belonging to the district a description would have been just as appropriate as that of the granites and greenstones. We find also a somewhat meagre account of the very interesting Pliocene strata of St. Erth. Surely a list of the commoner fossils should have been given to accompany the instructive description of the physical conditions under which the deposits were accumulated.

The Appendix on Mining by Mr. MacAlister contains a full and well-illustrated account of the many mines and of the more important lodes, with much statistical information.

An excellent colour-printed map accompanies this memoir. It is compounded of Sheets 351 and 358, and the price is 2*s.* 6*d.*

IV.—A GUIDE TO THE FOSSIL INVERTEBRATE ANIMALS IN THE DEPARTMENT OF GEOLOGY AND PALÆONTOLOGY IN THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W. 8vo; pp. 182, with 7 plates and 96 text-figures. London; printed by order of the Trustees. Price 1*s.*

CONGRATULATIONS to Dr. Arthur Smith Woodward, F.R.S., the Keeper of Geology, on the issue of an entirely new guide to the Fossil Invertebrata, which we learn from the preface by Sir E. Ray Lankester, the Director, has been written by Dr. Francis A. Bather, the Assistant Keeper, with the help of Mr. R. Bullen Newton, Mr. G. C. Crick, in the Mollusca; Mr. W. D. Lang, in the Bryozoa and Corals; Dr. W. T. Calman, in the Arthropoda. Thanks are also given to Mr. S. S. Buckman, Mr. H. W. Burrows, Mr. C. Davies Sherborn, and Mr. B. B. Woodward.

Commencing with the stratigraphical series in Gallery XI. occupying the wall-cases on the west side we find a collection of the various kinds of rocks found in Britain, arranged in the order of their age by the late Mr. R. Etheridge, F.R.S. Along the top of the case is a diagram showing the succession of these rocks from the newest to the oldest, as they might be seen in a continuous section across the country if one walked in a more or less straight line from east to west. Examples of the rocks themselves are placed on the shelves below, accompanied by numerous small sections of the strata as seen by observers in various parts of England. Affixed to the wall-cases is a series of small maps of Britain, each coloured to show the tract of country where the particular rock-group is exposed at or near to the surface, of which specimens are exhibited in the adjoining case. In the long section, at the top of the case, the number placed beneath each bed gives its approximate thickness in feet.

In connection with the subject of British strata reference is made to the important work done by William Smith, surnamed the "Father of English Geology," who was the first in this country to demonstrate the now fully recognised fact that each group of strata is marked by certain fossils. Therefore, when once a geologist knows the fossils characteristic of the various strata he can, if set down in any part of the country, readily determine on which bed in the geological series he is standing, if only he can find a few fossils to aid him. They are, in fact, the unerring 'spoor' to the geological hunter to guide him to his 'quarry.' A very good portrait of Smith is given in the Guide. This gallery is a veritable monument to William Smith; on the south wall is a copy of the original map geologically coloured by himself, and still in many respects a reliable guide. In the centre of the east wall is his bust (surrounded by maps and sections prepared by him) and surmounting a glazed case and cabinet containing his original collection, a monument to his genius as an original investigator and to his unwearying labour as a worker. In this gallery are also shown the collections of Mr. Searles V. Wood from the Crag, Mr. Edwards' from the Eocene, Mr. Sowerby's types of the Mineral Conchology, Dr. Davidson's Brachiopoda, Gilbertson's Carboniferous fossils, Brander's Eocene shells of Hampshire, Mr. König's types, and the few identifiable fossils of Sir Hans Sloane's Museum, the nucleus of the original British Museum (1753).

Nor do these important 'type' and stratigraphical collections exhaust this gallery, for at the further end, in wall-cases 6 and 7 and on the walls and opposite side, are brought together a very interesting series of specimens illustrating the work of dynamical, chemical, and organic agents—some caused by earth movements on a large scale, such as may be observed in the squeezing and crumpling of great masses of strata often miles in extent and thickness, as seen in mountain chains such as the Alps, the Andes, and the Himalayas, illustrated by models prepared by Lord Avebury and recently presented by him; others showing minute movements producing small faults, folds, and cleavage planes in rocks of various ages. Of chemical and concretionary structures there are again very many and varied examples, illustrated by 'dendritic markings,' 'cone-in-cone' structures, and a very wonderful series from the Magnesian Limestone of Durham, chiefly collected by Mr. G. Abbott, F.G.S., offering the most curious mimetic representations of organic structures, such as Stromatopora, and Corals in great variety, as well as globular and botryoidal forms. Many concretions also have organic nuclei, such as shells, leaves of plants, fishes, teeth, etc.; these are illustrated in great variety, as well as the castings of worms and curious tracks formed by annelides, and the footprints left by birds and reptiles.

Coming to remains of once living organisms in Gallery X, the Guide gives us figures of Foraminifera, Radiolarians, and Sponges, showing the siliceous or calcareous skeletons as they actually occur in the rocks. Many of these minute organisms, as well as the more massive growths of coral reefs, helped in the older seas of the world's past to build up organic rocks, furnishing strata of vast extent and great thickness, such, for instance, as the Nummulitic Limestone, which contributes largely to the Pyrenees, the Alps, the Atlas Range, the Himalayas, etc. In this gallery, and well illustrated in the Guidebook, are the Corals, the Stromatoporoids, and the Graptolites, whilst the centre and the eastern side are occupied by the fossil plants, including many silicified tree-trunks from Tertiary and Jurassic rocks, and a fine case of Cycadean stems, some cut and polished. The coal-plants, too, form a large and attractive series.

Gallery IX, although closed to the general public, is open to students and scientific workers, and contains the library and special study collections.

No. VIII contains the beautiful series of stone lilies, mostly from the Secondary, Carboniferous, and Silurian rocks. Many excellent figures are given in the Guide. After the stone lilies we come to the Starfishes and Sea Urchins in endless variety. To these succeed the Trilobites and other Crustacea, the giant *Pterygotus*, and the king crabs and scorpions, with many kinds of dragon flies and other insects from the Coal-measures upwards; and next these the Bryozoa and Brachiopoda. The west side of this large gallery is entirely given up to the display of the Gasteropoda and Lamellibranchiata, which, commencing with the glacial shells and those from raised beaches and the shells from the Peat and Lake deposits, go back in time to the earliest Silurian and Cambrian rocks.

The Mollusca, ancient and modern, form such a vast series that the higher forms, the Cephalopoda, Cuttle-fish, Nautili, Ammonites, and Orthocerata, require a whole gallery (No. VII) entirely to themselves. Probably in no other museum in the world can such a display of the chambered shelled Cephalopods be seen as is exhibited in this gallery, of which the Keeper of the Geological Department, Dr. A. Smith Woodward, may be justly proud. The largest coiled British Ammonite is a *Pachydiscus leptophyllus*, 3 ft. 8 in. in diameter, from the Chalk of Rottingdean, near Brighton. But this is far surpassed by *P. Seppenradensis*, an Ammonite from the Chalk of Westphalia, a cast of the shell of which, having a diameter of 6 ft. 8 in., is fixed on the north wall.

But we must end this notice by commending the lover of natural history to purchase a copy of this very admirable Guide, which is really a textbook for one shilling, beautifully illustrated with 7 plates and 96 text-figures admirably executed, forming a most attractive handbook for the student and the casual visitor alike. We compliment the Keeper of Geology and his Assistant Keeper, Dr. F. A. Bather, the writer, and his colleagues, who together have produced so splendid a shilling's worth.

V.—MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

MEMOIR OF THE GEOLOGICAL STRUCTURE OF THE NORTH-WEST HIGHLANDS OF SCOTLAND. By B. N. PEACH, LL.D., F.R.S., JOHN HORNE, LL.D., F.R.S., the late W. GUNN, C. T. CLOUGH, M.A., F.G.S., and L. W. HINXMAN, B.A.; with Petrological Chapters and Notes by J. J. H. TEALL, M.A., D.Sc., F.R.S. Edited by Sir ARCHIBALD GEIKIE, K.C.B., D.C.L., Sec. R.S. Edinburgh, W. & A. K. Johnston, Ltd.; Glasgow, Jas. Hedderwick & Sons, Ltd. 8vo; pp. xviii and 670, with 52 plates and a geological map of the North-West Highlands of Scotland, and 66 figures in text. Price 10*s*. 6*d*. (Preliminary notice.)

THIS memoir, on the geological structure of the North-West Highlands of Scotland, is one of the most important which has been issued by the Geological Survey, as it relates to a region which has become classic for the study of the more powerful movements whereby the earth's crust has been affected.

The opening chapter gives a brief account of the various rock-groups to be found in that region, their geological relations, and the remarkable structures which they present in the field. It is followed by a historical account of the development of the research, special reference being made to the controversy between Sir R. I. Murchison and Prof. Nicol regarding the structure of the North-West Highlands, and to the investigations which led to a settlement of the dispute.

A detailed account is given of the structure, distribution, and petrography of the Lewisian Gneiss and Torridon Sandstone along the western portions of the counties of Sutherland and Ross. The various subdivisions of the Cambrian formation are enumerated, and, for the first time, a description is furnished of the distribution and organic contents of the *Olenellus* zone, which has been detected and traced by the Geological Survey for 100 miles.

But the feature which renders the volume of exceptional interest to geologists all over the world is the description and illustration of those great displacements of the earth's crust, whereby slices of the older rocks have been driven westwards for miles and made to rest on younger strata. The detailed evidence in proof of such movements is set forth in part iv.

The concluding section of the work (part v) gives a brief account of the petrography, distribution, and geological relations of the Eastern Schists, which lie above the most easterly of the great planes of disruption in that region. The age of those crystalline schists is still unsolved.

The volume is illustrated by 52 plates, 66 text-figures, and a colour-printed geological map of the area between the north coast of Sutherland and Sleat in Skye on the scale of four miles to one inch.

Copies may be obtained from any agents for the sale of Ordnance Survey maps, or through Messrs. Dulau & Co., 37, Soho Square, W., from the Ordnance Survey Office, Southampton. Price 10*s*. 6*d*. (postage 10*d*. additional).

A full review of this important work will appear in next month's GEOLOGICAL MAGAZINE.

REPORTS AND PROCEEDINGS.

CENTENARY OF THE GEOLOGICAL SOCIETY OF LONDON.

The Centenary Celebration of the Geological Society of London, to which we drew the attention of our readers in the GEOLOGICAL MAGAZINE for January last, pp. 1–3, and again in our September number, pp. 385–389, has come and gone. The numerous foreign and Colonial visitors have been hospitably entertained; geological excursions and visits to our Museums and Universities had previously been arranged for their honour and gratification. The President, Secretaries, Treasurer, and Council have all exerted themselves to render the stay of such distinguished guests as agreeable as possible, and it is to be hoped they will carry away with them pleasant memories of their English visit.

On Thursday, the 26th September, a reception was held at the Institution of Civil Engineers at 11 o'clock, when the delegates from Foreign and British Scientific Societies and Academies offered congratulatory addresses to the President, Sir Archibald Geikie, K.C.B., and he personally was presented with the Gold Medal of the Institution of Mining and Metallurgy, which was handed to him by C. J. Alford, Esq., F.G.S., on behalf of that body.

At 3 o'clock the President read his address on "The State of Geology at the Time of the Foundation of the Geological Society, in 1807." He gave a sketch of our science a hundred years ago, and described the work of its first President, George Bellas Greenough, and its other founders. He referred to the labours of William Smith, known as "Strata Smith," and named by Sedgwick "the Father of English Geology." He pictured the state of knowledge regarding the structure and history of the earth as it was at the beginning of the last century, and of the conflict of opinions at the time which raged between the followers of Werner and Hutton, the Neptunists and the Plutonists. He showed how much the miner and mineralogist had to do with the origin of the science and the great advance of geological knowledge at the present time.

A banquet was held in the evening at the Whitehall Rooms of the Hôtel Métropole, at which 291 were present. After the President had proposed the toast of the King and the heads of Foreign Countries, Professor A. de Lapparent proposed that of the Geological Society, which was followed by speeches from Professor Lapworth and other distinguished Fellows and delegates.

The Universities of Oxford and Cambridge on the 30th September and 1st October conferred respectively degrees as follows:—Oxford, D.Sc. *honoris causâ*, Professor Charles Barrois, Professor Albert Heim, Professor Alfred Lacroix, Dr. Hans H. Reusch, Professor Albrecht Penck, and Professor Geheimrath Ferdinand Zirkel. Cambridge, Sc.D. *honoris causâ*: Professor W. C. Brögger, Professor Hermann Credner, Professor L. Dollo, Professor A. de Lapparent, and Professor A. G.

Nathorst. Professor Geheimrath H. Rosenbusch could not be present to receive his degree.

Over 470 cards of identification were issued by the Society to Fellows, delegates, and guests attending the Centenary. Sixteen Foreign Members and 14 Foreign Correspondents, besides many other foreign and Colonial visitors, were present. The following were the countries represented: Austria-Hungary, Argentine Confederation, Belgium, Denmark, Egypt, France, German Empire, Greece, Holland, Italy, Japan, Mexico, Norway, Portugal, Russia, Sweden, Switzerland, United States, also the Dominion of Canada, India, South Africa, the Commonwealth of Australia, and the Dominion of New Zealand.

CORRESPONDENCE.

NOMENCLATURE OF AUSTRALIAN SILURIAN OPHIURIDS.

SIR,—Presumably this heading to Mr. Chapman's welcome letter (GEOL. MAG., Oct. 1907, p. 479) does not imply that Silurian Ophiurids are to be excepted from the laws of nomenclature when they occur at the Antipodes. Yet the difference between us could scarcely have arisen had Mr. Chapman felt himself bound by certain rules adopted at all recent sessions of the International Congress of Zoologists. But he is not even loyal to the Stricklandian code, preferring rather to follow 'an unwritten rule.' Perusal of the modern code, of which I believe Mr. Chapman has now received a copy, will, I hope, show him that my remarks concerning *Sturtzura* were in simple accordance with elementary rules. It is not my business to defend those rules, but since Mr. Chapman assumes that his own views are shared by others, I ask leave to put the real point in dispute as clearly as I can.

The object of selecting a type—whether type-specimen (holotype) of a species, or type-species (genotype) of a genus—is, not to indicate to one's readers what one believes to be the most characteristic form (norm) of the species or genus under discussion, but to fix on a form according to which the species or genus shall stand or fall. Experience has taught us that we all make mistakes in our descriptions, and that the most carefully constructed diagnosis may prove erroneous. A nomenclature based on diagnoses and on various rational or ethical principles has been tried and found wanting. Therefore zoologists have said: "We will exclude all these sources of human error from the foundations of our nomenclature so far as is possible, and we will base our work on concrete specimens."

Professor Gregory fixed on *Protaster brisingoides* as the genotype of *Sturtzura*. His interpretation may have been right or wrong, but this at any rate is sure: what *P. brisingoides* is, the same is *Sturtzura*; whatever the diagnosis may be, all species congeneric with *P. brisingoides* are also *Sturtzura*, unless they include the genotype of a prior genus. For example, if *P. brisingoides* be congeneric with *P. sedgwicki*, *Sturtzura* yields to the prior *Protaster*; but if it be congeneric only with *P. leptosoma* as Gregory maintained, or only with *P. biforis* as I have hypothetically imagined, then the name *Sturtzura* stands. (Internat. Rules, 1905, Art. 29.)

That the rule referred to in the phrase "once a synonym, always a synonym" has no bearing on either of these suppositions, is evident when its meaning is understood. The rule, in fact, simply states that a generic name once used in zoological nomenclature cannot be used for any subsequent genus that does not include the original genotype, even when the name as first used has proved to be a synonym. But if the rule does not forbid the resuscitation of *Sturtzura* for a genus containing the genotype *S. brisingoides*, it certainly does forbid its use for a genus comprising only *S. leptosoma* and *S. leptosomoides*. (Internat. Rules, 1905, Art. 36.)

Mr. Chapman may not approve of these rules, and I do not pretend that I like them all myself. But in these matters of form it is surely better that individuals should come into line with the great majority of their colleagues.

My protest against the composition of certain names was not made from the standpoint of a museum curator, as Mr. Chapman seems to suppose, but from that of the compilers of the Stricklandian code, who desired to render "our scientific language palatable to the scholar and the man of taste." If a name is held to have no meaning, let it at least be euphonious; but if it is intended to have a meaning, that need not be a ridiculous one.

As for the more important matter—the homologies of the arm-ossicles, there seems no grave objection to the compromise now proposed by Mr. Chapman. But whether the ambulacrals consist of one piece as I suggested, or of two pieces as he now suggests, will probably not be decided until we find specimens with the stereom undissolved.

F. A. Bather.

London, 7 *October*, 1907.

COLLODION AS A PRESERVATIVE FOR FOSSILS.

Sir,—Dr. Bather's interesting article on collodion imprints reminds me of an intention I have long had of communicating to you another use for collodion. The usual method of preserving fragile fossils by application of a hot gelatine solution is one which I have always found troublesome and unsatisfactory. Some years ago a student suggested to me that a solution of collodion would penetrate more readily, could be used at ordinary temperatures, and would become solid more slowly. He gave me some solution that he was using for some other purpose—a saturated solution of gun-cotton in equal parts of amyl acetate and ethyl alcohol. I found this answer very well, both for preventing the flaking of delicate fossils and for mending broken ones. Small specimens can be simply immersed in the solution, left there (in a corked tube) for an indefinite period, and finally lifted out and dried. Larger ones may be painted over, several times if necessary. I have by this means mended, among other things, broken specimens from Wenlock Limestone and Chalk Marl, and even large Jurassic oysters, though in the last case they are apt to break again on ordinary handling. I have been too lazy to experiment with variations on the original recipe given me, but from conversations with several chemists I gather that a simple solution of collodion in amyl acetate would probably act as well as the one I have been using. A. Morley Davies.

Underwood, Winchmore Hill, Amersham.
21st October, 1907.

SALINE SOLUTIONS AND ORES.

Sir,—The Geological Magazine has afforded me the opportunity to champion many unpopular causes scouted elsewhere. Perhaps the greatest offender has been the significance of chlorides in granitic quartzes. The ubiquity of chlorides throughout the Dartmoor mass, and, so far as I am aware, in the Cornish elvans also, impressed me greatly. There must be some reason for it. I endeavoured to account for their origin, but could see no practical importance in what seemed to be a purely petrological puzzle.

I now see that Mr. E. C. Sullivan, in discussing the interaction between minerals and water-solutions, points out that "salt solutions, as decomposing agents, are much more active than pure water, and are comparable with acids in this respect." Mr. H. Foster Bain also points out, with reference to zinc and lead, that "the ore bodies are doubtless due to concentration or re-concentration through the action of underground waters" (*Nature*, vol. lxxvi, p. 559). Here we have a direct connection indicated between the Devon and Cornish mineral veins and the ubiquitous chlorides of potassium or sodium; also a possible explanation of the common connection between chlorides and the schorl rocks of the Western counties.

If I can get metallurgists and chemists to perceive that chlorides in quartzes may have a distinct bearing on practical mining, and above all money-making, the investigation of the chloride problem will be secured, and there will be no need for me to further trouble my many geological friends by my importunity.

When a most distinguished authority said that I based my world on an elephant, the elephant on a tortoise, and the tortoise on microscopic grains of chloride of sodium, he stated the absolute truth. The chlorides, both as to their origin and their significance, have puzzled me more than any other petrological conundrum.

I am fully convinced that petrologists have no idea how ubiquitous the chlorides are in the Western granites. One amateur friend assures me they are very rare. An expert friend, to whose diagnosis I submit unreservedly, once sent me a slide for me to say whether there were *any* chlorides in it. The slide was mounted with an asphaltum ring, precluding the use of a high-powered objective, and the cover was not too thin. It abounded in chlorides—in fact, was rather a good example. It once took me about three evenings' work with the $\frac{1}{16}$ to conquer one refractory slide, but at last I detected one very minute cube. That of course sufficed to prove the presence of chlorides when the quartzes crystallised. Of course, my point is the diffusion of chlorides throughout the district, not the optical abundance of cubes in every slide. Moreover, brine solutions cannot be detected unless sufficiently concentrated to deposit crystals. It is quite likely that in the slide referred to all the fluid inclusions are saline, even though only one of them can be proved by the microscope.

A. R. HUNT.

FOXWORTHY, MORETONHAMPSTEAD.
2nd October, 1907.

OBITUARY.

PROFESSOR CHARLES STEWART, LL.D., M.R.C.S., F.R.S., F.L.S., F.R.M.S.

BORN 1840. DIED SEPTEMBER 27, 1907.

BY the death of Professor Charles Stewart, which has occurred after a somewhat protracted illness, the Royal College of Surgeons of England has lost one who has successfully filled the office of conservator of the museum for the past twenty-three years. After attending as a medical student at St. Bartholomew's Hospital Professor Stewart became a member of the Royal College of Surgeons in the year 1862. He was admitted a Fellow of the Linnæan Society in 1866, and was President of that body during the years 1890 to 1894, and in the following year served as Vice-President. Professor Stewart was also a Fellow and Vice-President of the Royal Microscopical Society, and became one of its honorary secretaries in 1878. He was Treasurer of the Anatomical Society of Great Britain and Ireland from its foundation until 1891. During the period 1894–1897 he held the office of Fullerian Professor of Physiology at the Royal Institution, and delivered several evening lectures at the same place. He was admitted a Fellow of the Royal Society in 1896, and obtained the honorary LL.D. of Aberdeen University. Before being appointed Conservator of the College of Surgeons' Museum Professor Stewart was curator of the museum of St. Thomas's Hospital, lecturer on Comparative Anatomy, and joint lecturer with Professor John Harley on Physiology at that institution. He was subsequently appointed Professor of Biology and Physiology at Bedford College. In the year following his appointment at the College of Surgeons he was elected Hunterian Professor of Human and Comparative Anatomy, and held the post until the year 1894. The true value of Professor Stewart's scientific work is not to be judged solely by his writings, which, in spite of the vast extent of his knowledge gained from his personal observations, were comparatively few in number, but it is to be seen rather on the shelves of the College Museum in the unrivalled series of preparations and dissections by which he sought, in continuation of the work of previous Conservators, to illustrate important phases in the evolution of the organic world and thus to amplify the original scheme of John Hunter, whose collection forms the nucleus of the College museum. Professor

Stewart was a master in the art of lecturing. His easy and lucid style, combined with a rare power of swift and effective drawing on the blackboard, would have made his addresses notable quite apart from the peculiar charm of his delivery.—*The Morning Post*, Saturday, September 28th, 1907.

EDMUND MOJSISOVICS VON MOJSVAR, Sc.D.

We regret to record the death at Mallnitz, on the 2nd October, of the eminent Austro-Hungarian geologist and palæontologist, Johann August Georg Edmund Mojsisovics, Edler von Mojsvár, Sc.D. Camb., Foreign Memb. Geol. Soc. Lond., author of numerous memoirs on the Cephalopoda of the Austrian Trias, to the description and illustration of which he devoted very many years of his life. He was a member of the k.k. Geologischen Reichsanstalt in Vienna; and usually resided at Strohgasse, 26, Vienna 3/3. We hope to give a fuller notice of Dr. E. Mojsisovics later on.

REV. RICHARD BARON, F.L.S., F.G.S.

Born 1847. Died October 12, 1907.

We regret to record the death (from heart-failure, following an attack of malarial fever) of the Rev. Richard Baron, who for thirty-five years was engaged in missionary work at Antananarivo, Madagascar, in connection with the London Missionary Society. Mr. Baron was a frequent contributor to the *Antananarivo Annual*, and took an earnest interest in the botany, geology, and palæontology of Madagascar. In March, 1889, he communicated to the Geological Society of London, through the Director-General of the Geological Survey, some interesting notes on the geology of Madagascar, with an appendix on some fossils collected by him, by Mr. R. Bullen Newton, F.G.S., of the British Museum (Natural History). At the same meeting, March 6th, 1889, Dr. F. H. Hatch, F.G.S., contributed some notes on the petrographical characters of some rocks collected by Mr. Baron (Geol. Mag., 1889, pp. 234–235, and Quart. Journ. Geol. Soc., 1889, vol. xiv, pp. 305–331, pl. xiii, and map). A second extensive collection of Invertebrate fossils was made by Mr. Baron in 1891, during a journey of 1,200 miles, in which he visited the east coast, the northern end of Madagascar, and the north-west coast and adjacent islands. His description of the geology and the rocks examined form the subject of an excellent paper read before the Geological Society, November 21st, 1894 (Quart. Journ. Geol. Soc., vol. li, 1895, pp. 57–71, pl. i), to which Mr. R. B. Newton contributed a description of the fossils obtained by Mr. Baron (op. cit., pp. 72–92, pls. ii and iii).

From Mr. Baron's observations and collections we learn that sedimentary rocks occur mainly on the western and southern sides of the island. From the fossils brought home it appears that the following formations are represented, namely: Eocene, Upper Cretaceous, Neocomian, Oxfordian, Lower Oolitic, and Liassic rocks.

Possibly some of the slaty beds may prove to be of Silurian or Cambrian age. Recent deposits fringe the coast and are largely developed on the southern part of the island. The alluvial and peat deposits and old lake-bed accumulations have been largely explored by Dr. C. I. Forsyth Major and later by Mr. Standing, and have yielded numerous genera of *Nesopithecus*, *Megaladapis*, *Hippopotamus*, Crocodilia, Chelonia, *Æpyornis*, etc. Mr. Baron also discovered the fossil remains of one of those long-snouted Gavial-like Crocodilia, considered to be of Lower Oolitic age, which was described and figured by Mr. R. B. Newton in the Geol. Mag., 1893, pp. 193–198, Pl. IX, under the name of *Steneosaurus Baroni*.

It is interesting to mention that in the rocks described in 1889 by the Rev. Richard Baron as Jurassic in North-West Madagascar, the remains of a Sauropodous Dinosaur, referred by Mr. R. Lydekker to *Bothriospondylus Madagascariensis*, should have been obtained by Mr. J. L. Last, closely resembling forms found near Oxford, also at Fletton, near Peterborough, and in the Kimeridge Clay of Wiltshire (see Quart. Journ. Geol. Soc., 1895, vol. li, pp. 329–336).

Mr. Baron furthermore communicated to the Linnean Society a valuable paper on "The Flora of Madagascar" (Journ. Linn. Soc. Bot., vol. xxv, 1888, pp. 246–350), and was the author of the first geological textbook in Malagasy, 1896, pp. 191, with numerous illustrations in the text, a copy of which is preserved in the Geological Department of the British Museum.

In 1891 the Council of the Geological Society of London marked their appreciation of Mr. Baron's geological work in Madagascar by the award of the balance of the proceeds of the Murchison Geological Fund, in testimony of the interest taken by them in the geological work which amid many discouragements he was carrying on in Madagascar.

Geologists owe a great debt of gratitude to such men as the Rev. Richard Baron and Mr. Standing in Madagascar, and the Rev. Samuel Couling, M.A., at Ching-chou-fu, Kiao-chow, North China, who in such distant regions and amid inimical surroundings have, with but little encouragement, carried on most valuable scientific researches and stimulated others to follow where they have led the way.

MISCELLANEOUS.

Serviço Geologico e Mineralogico do Brazil.—By a decree approved January 10th, 1907, the Federal Government of Brazil has established a Geological Survey with the title of Serviço Geologico e Mineralogico do Brazil, as a bureau of the Department of Industry, Highways, and Public Works. The service has already been organized, and systematic work has been commenced. The results of the Survey's work will be published as rapidly as possible. Communications and exchanges should be addressed to the office of the service at No. 49, Rua da Quitanda, Rio de Janeiro, Brazil. Orville A. Derby, Chief.

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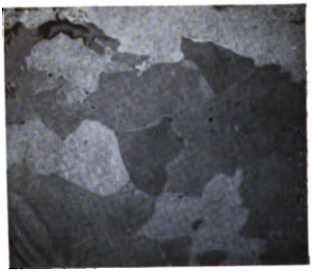

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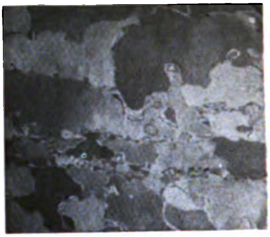

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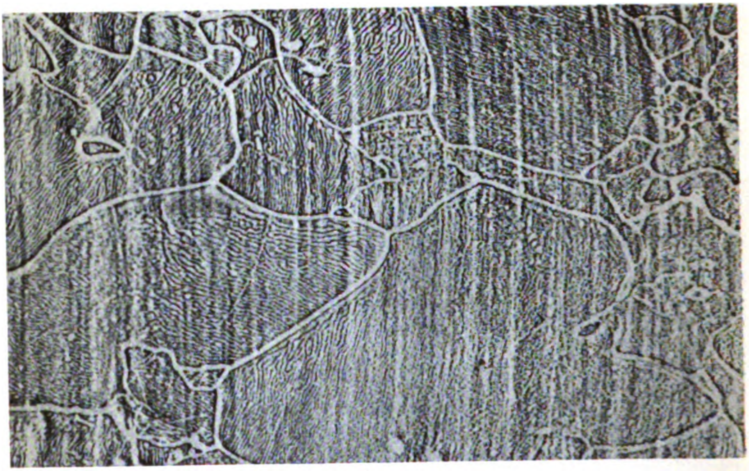

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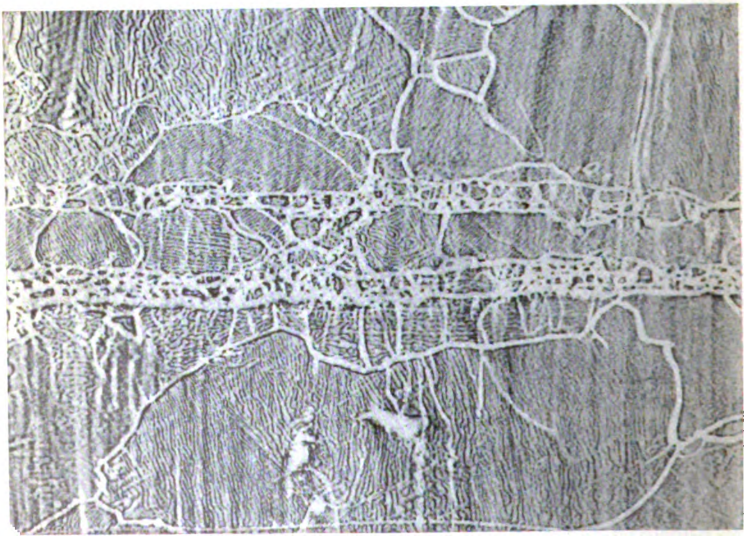

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. 1, 2.—Photographic Reproductions of thin slices of ice 0.3 inch in thickness.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. XII.—DECEMBER, 1907.

ORIGINAL ARTICLES.

I.—THE STRUCTURE OF GLACIER ICE.

By R. M. DEELEY, M.I.C.E., F.G.S.

(PLATES XXIII AND XXIV.)

IN the GEOLOGICAL MAGAZINE for April, 1895, p. 152, the results of some observations made by Mr. George Fletcher, F.G.S., and myself on the structure of glacier ice were given.

Thin plates of ice were made by cutting and melting, and then examined in polarized light. In all cases it was found that the individual crystals were in close contact, there being no evidence of the presence of a eutectic separating them. The crystals in the same piece varied very greatly in size, and had very irregular outlines.

As the sections which we figured were in all cases drawn by hand, I thought it advisable to construct a special form of instrument with which to obtain actual photographs of thin sections of glacier ice. The instrument eventually used consisted of two bundles of thin glass plates, one being used as a polarizer and the other as an analyser. They were fixed vertically above each other, and between them was the glass stage upon which the thin ice sections rested. Below the analyser was a small lens throwing the image of the ice section upon a photographic plate.

Last Summer, accompanied by Mr. H. Arnold-Bemrose, M.A., F.G.S., who kindly assisted me in the matter, I visited the Furka Pass, and we obtained photographs of the ice of the Rhône Glacier.

Figs. 1 and 2 are full-sized photographs of thin slices of ice. Samples with small crystals were selected, so as to bring many crystals within the limits of the field. The ice section was about ·03 inch thick, and where the surface between two crystals is at an angle with the glass plate upon which the ice section rested, interference fringes are consequently to be seen.

In the ice caves we noticed the beautifully lined surfaces of the crystals of which the glacier is formed, and were successful, by adopting very simple means, in obtaining correct reproductions of the structure. The lines consist of alternate ridges and furrows, and we found that by placing a piece of paper upon the ice surface and rubbing with a pencil, very beautiful copies could be obtained. Figs. 3 to 7 are reproductions of these.

The structure on the glacier ice surface shown by these rubbings results from the slow melting and evaporation of the surface; for if by the warm hand or other means the surface be melted until it is quite smooth, in the course of a few hours the structure will again develop. Melting takes place most actively between the crystals, forming comparatively wide channels, shown in the rubbings by the broad white lines. The small white dots are air bubbles.

In Fig. 3 the crystalline grains vary largely in size and have very irregular outlines. The markings on their surfaces much resemble 'finger-prints,' and the lines run at various angles. In Fig. 4 two main lines of fracture run parallel with each other across the ice. They are not quite straight, the boundaries of the individual grains having moved somewhat owing to the growth of some grains at the expense of others, since shear took place. One line of shear in Fig. 5, though somewhat bent, is almost unaffected by this; but in Figs. 6 and 7 marked changes have taken place in what were originally straight lines of shear. It will be noticed that the coarseness of the ridges and furrows on the surfaces of the grains varies very much. This is probably due to the angle the optic axis bears to the lined surface.

McConnell[1] and O. Mügge[2] have shown that an ice crystal behaves as if it consisted of an infinite number of very thin, non-expansible, but perfectly flexible layers, somewhat like paper, between the different sheets of which there is a sticky substance, so that the sheets can only with difficulty glide over each other. The layers, being non-expansible and perpendicular to the optic axis, in the act of bending slide over each other; but the crystal axes still remain at all points perpendicular to the bent surface. Mügge states that the slipping or sliding did not commence in the case he tried until the stress reached a certain limit, but it does not appear that the experiment was quite decisive on this point, as the ice used was probably not quite homogeneous. Whether the ice is plastic or viscous at right angles to the optic axis is therefore uncertain.

Striations on ice crystals were noticed by Mügge. He states that broken surfaces of ice, especially those of bent bars, almost always show a fine striation at right angles to the optic axis; but is unable to state whether the striations observed on glacier grains run parallel to the base and are identical with the striation of translation. I have never seen these striations except on strained ice, and although proof that the striations on glacier grains run parallel to the base is required, I am strongly inclined to think that they do, and that they develop on such surfaces by evaporation owing to the irregular stresses in the crystals. If this view should prove correct, the irregularities in the striations shown on the ice rubbings indicate to us the direction of the optic axis and show that what may be regarded as large crystals are by no means symmetrical.

The greater portion of the ice of a glacier has the structure shown in Fig. 3. Here the grains are quite irregular, large ones and small

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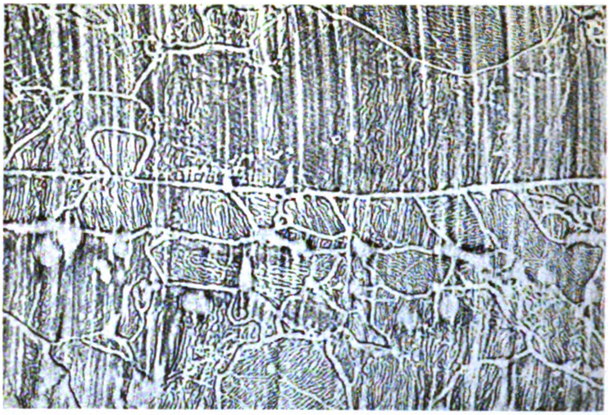
[1] Proc. Roy. Soc., 1890, pp. 48, 259, and 1891, pp. 49, 323.

[2] Jahrb. für Min., 1895, p. 211.



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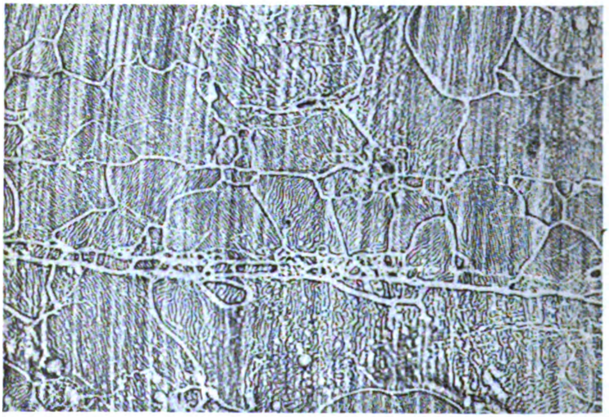

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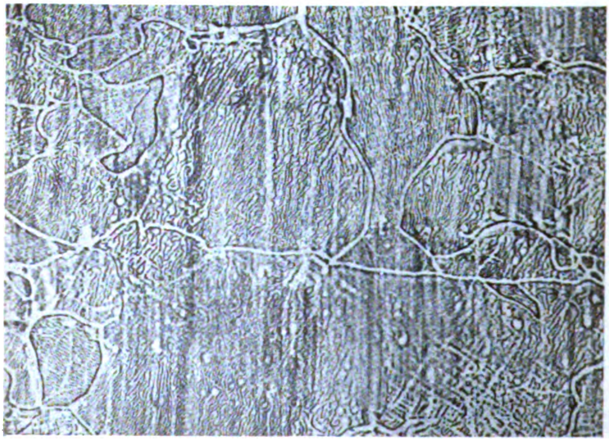

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Figs. 5-7.—Reproductions of actual surface markings on ice in glacier ice caves, consisting of ridges and furrows.

ones lying side by side. Shear planes are, however, constantly forming and breaking up, and displacing the parts of the crystals more or less. Figs. 4, 5, and 6 show this clearly. As, however, the ice grains are continually changing shape, some growing and others decreasing in size, these shear planes in time disappear as they have partly done in Fig. 7.

In the paper already referred to this interchange of molecules, which causes some glacier grains to grow and others to decrease, was regarded as the cause of glacier motion, and should produce true viscous motion in the glacier as a whole, even though it may be unsound to regard an ice crystal as truly viscous at right angles to the optic axis.

EXPLANATION OF PLATES XXIII AND XXIV.

FIGS. 1–2. Full-sized photographs of thin slices of ice, about 0·03 inch thick.

,, 3–7. Lines and surface-markings obtained by taking rubbings of the actual surfaces of the glacier ice in ice-caves. They consist of alternate ridges and furrows.

II.—THE RELATIONSHIPS OF THE 'SPARASSODONTA.'[1]

By Dr. W. D. MATTHEW, of the American Museum of Natural History, New York.

THE Sparassodonta are an interesting group of extinct mammals found in the Tertiary formations of Patagonia. They appear to have taken the place of true Carnivora in South America during most of the Tertiary period, as the Carnivorous Marsupials do in the modern fauna of Australia. Their relationship has been in dispute since they were first made known to science by the distinguished South American palæontologist Florentino Ameghino. In dental formula and other characters of the teeth and jaws they agree with the Carnivorous Marsupials, and show a high degree of adaptive specialization for predaceous habits. Dr. Ameghino was able to determine, however, from specimens in his collection, that the replacement of the premolars, in certain genera at least, was more complete than in modern marsupials, and approached that of the placental carnivora. He regarded them, therefore, as an intermediate group, ancestral to the Creodonta and modern Carnivora. Mr. Tomes, in his interesting study of the enamel structure of the Creodonta and allied groups, has recently shown that in one genus of Sparassodonts the enamel shows the more highly differentiated structure of the true Carnivora, instead of the more primitive structure of Marsupial Carnivores. The collections made by the Princeton and American Museums in the Santa Cruz formation of Patagonia contain a splendid series of Sparassodont remains, including skulls and skeletons of the principal genera, which have recently been exhaustively studied by Dr. Sinclair. These show that the Sparassodonts agree with Marsupials, and especially with *Thylacinus* in almost all the distinctive features of dentition, skull, and skeleton characters by which they are separated from the placental mammals. Mr. Sinclair gives an extended list of the marsupial characters of the group, embracing twenty or thirty more or less independent points of structure, and including most of the important osteological peculiarities of modern Marsupials. There are, however, certain points of difference.

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[1] "Marsupials or Creodonts?" R. L. in *Nature*, March 21st, 1907. C. S. Tomes, "On the Minute Structure of the Teeth of Creodonta, etc.": Proc. Zool. Soc. London, June, 1906. W. J. Sinclair, "Marsupialia of the Santa Cruz Beds": Reports of the Princeton Expeditions to Patagonia, vol. iv, part 3, Sept., 1906.

1. Sinclair's material did not enable him to demonstrate any more extensive replacement of the premolars than prevails among modern Marsupials, viz. p. 4 only. Ameghino states that in *Borhyæna* the canine and in *Cladosictis* the canine and second premolar are also preceded by milk-teeth.

2. Palatine vacuities, characteristic of most Marsupials, as well as some placental mammals, are lacking in this group.

3. There are no indications of marsupial bones. This does not necessarily mean that they were absent; they may have been small and without distinct articular facets, and not preserved in the fossil skeleton. They are vestigial in *Thylacinus*.

4. Enamel structure as in Placental Carnivora. This is known only in one genus, *Borhyæna*, the largest and most specialized of the group. Mr. Tomes' paper was not published at the time Dr. Sinclair's monograph was written, so that this important point was unknown to him.

On the other hand, we have—

1. Dental formula typically marsupial, with three premolars and four true molars, as opposed to the placental formula with four premolars and three true molars.

2. The characters of the basicranial region agree with Marsupials, in some respects also with Insectivores, and differ from Creodonts and modern Carnivores.

3. The malar bar is extended posteriorly to take part in the preglenoid process.

4. The posterior border of the palate is perforated by a large foramen on either side of the posterior nares.

5. Post-zygomatic and sub-squamosal foramina present.

6. Transverse process of seventh cervical vertebra perforated by vertebral artery.

7. The arrangement of carpals and tarsals is in fairly close agreement with Carnivorous Marsupials, and decidedly different from the type common to Creodonts and the less specialized Carnivora. In particular, the small lunar and large magnum, the peculiar type of astragalus, etc., agree with Marsupials generally and differ from Placentals generally, the agreement and difference being very marked when comparison is confined to Carnivorous Marsupials and Placentals.

Various other characters are listed by Dr. Sinclair, but the above appear to be the most essential. In the writer's opinion any one of these outweighs in importance all of the characters except the last, in which the Sparassodonts differ from Marsupials. The enamel structure is doubtless a character of high importance if constant throughout the group, but even if it proves to be so it admits of an explanation which would bring it in accord with the marsupial relationships of the group.

Dr. Lydekker is not convinced by the evidence adduced by Sinclair. He regards the Sparassodonts as descended from Creodonts.

Concerning the dental formula he observes: "The dental formula of the cheek-teeth, in the opinion of Dr. J. L. Wortman and the present writer, is identical in the Sparassodonts, Carnivorous Marsupials, and Creodonts, and is therefore of no importance except to indicate the mutual relationship of all three groups." This assertion can only be taken to mean that the dental formula in Marsupials and Sparassodonts is *derived* from that of Creodonts by reduction of the successional premolars. This theory is very generally held. But for 'Creodonts' might just as well have been substituted Carnivora or Eutheria in general. Accepting Dr. Lydekker's view as to the derivation of one formula from the other, the fact remains that they *are* distinct and show no approximation among the oldest known Tertiary representatives of the two groups. Carnivorous Marsupials, perfectly typical as to dental formula, inflection of the jaw, etc., occur with the early Creodonts in the Eocene and Oligocene formations of North America and in the Oligocene of Europe. Indeed, if we may rely on the imperfectly known Jurassic mammals the distinction between the two formulas dates well back into the Mesozoic.

In one or more genera of the Sparassodonta, Dr. Ameghino has found evidence that the canines and the second post-canine tooth (premolar), as well as the third, is replaced by a successional tooth. In others, so far as known, the third premolar only is replaced, as in modern Marsupials. This does not affect the dental formula. The fourth post-canine tooth is always molariform, belongs to the lacteal series, and is never replaced by a successional tooth. In no Creodont is any tendency observed toward the retention of the fourth milk premolar in the permanent series; the number of permanent molars does not exceed three, and the replacement is of the normal Eutherian type.

The absence of palatal vacuities among the Santa Cruz Sparassodonta and of epipubic bones in one genus cannot be considered as of equal importance with the dental formula and other characters listed above, since they are neither constantly nor exclusively present among Marsupials. Epipubic bones are vestigial in *Thylacinus*, the most nearly related form among modern Marsupials; their presence in less specialized types of ancient and modern Marsupials indicates them as a primitive character of the order lost in certain specialized races. Even if this character were known to be constant throughout the Sparassodonta it would merely accord with the general trend of their specialization, and is surely no argument for removing them from the Marsupialia. As for the absence of palatine vacuities in Sparassodonts, this feature can hardly be given great weight since palatal vacuities are absent in several modern Marsupials and present in several Insectivores. Whether the vacuities are primary or secondary is not very clear; it does not follow, at all events, that because the Sparassodonts are related to *Thylacinus* they are directly ancestral, and the presence of palatine vacuities in the modern genus may be an archaic character lost by the South American group but retained along with several other more primitive characters by the modern Australian genus. Palatal vacuities are absent in the primitive Erinaceid *Proterix* and in the Leptictidæ, from which family the hedgehogs are probably derivable, but are present in the modern hedgehog; this may be a parallel case. The facial vacuities of the Artiodactyla are certainly secondary developments and are independently developed in different families. The hypothesis that they are retained from reptilian ancestry is certainly not supported by any adequate evidence. Nevertheless, the palatal vacuities of Marsupials may date back to the earliest differentiation of the order, and their loss be an independent specialization in each group where it occurs; the uniform presence of the character in all the more generalized members of the order seems to point to this conclusion.

The principal marsupial characters of the Sparassodonta thus appear to be of much greater weight than anything that can be adduced in favour of their placental relationship. They are definite, constant, and exclusive characters of the marsupial skeleton, and no material approximation to any of them occurs among the Creodonts.[1] There is but one character of real importance which appears to connect the Sparassodonts with the Creodonts and modern Carnivora, viz. the histological structure of the enamel. The investigations of Mr. Tomes on the enamel structure in Marsupials, Creodonts, and Carnivora have yielded some very significant results, and it may be as well to summarize them briefly and point out what their real bearing is. He shows that—

1. The marsupial enamel is distinguished by two principal characters: (*a*) it is penetrated by tubes from the dentine, and is thus less completely differentiated; (*b*) its component prisms are parallel, lacking the interlacing arrangement of Carnivora.

2. In the Inadaptive Creodonts (*Sinopa* and *Hyænodon*, family Hyænodontidæ; *Oxyæna*, family Oxyænidæ; *Pachyæna* and *Mesonyx*, family Mesonychidæ) the enamel structure is identical with that of modern Carnivora.

3. In the Adaptive Creodont *Didymictis* and the primitive Cynoid *Cynodictis* the enamel is not penetrated by tubes from the dentine, but its component prisms are parallel.

4. In *Borhyæna* among the Sparassodonta the enamel structure is that of Inadaptive Creodonts and modern Carnivora.

5. Traces of the more primitive enamel structure are seen in the lower orders of Placentals (Insectivora and Rodents); and in *Hyrax*, the most primitive of hoofed Placentals, the enamel is like that of Marsupials.

6. Among the Marsupials, the more specialized carnivorous types exhibit the nearest approximation to the higher development of the enamel characteristic of Placentals. *Phascolomys* alone among the Diprotodonta resembles the Placentals in its enamel structure.

From these facts we may deduce that—

1. The Marsupials are not derivable from the Creodonta, since their enamel structure is much more primitive.

2. The Creodonta are closely related to the Fissipede Carnivora, and, like them, show a high grade of evolution in enamel structure.

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[1] There is a slight inflection of the jaw in the later Mesonychidæ, but it is not at all like the marsupial inflection. Certain other alleged approximations are equally slight, superficial, or unimportant.

3. The Adaptive Creodonts are more primitive than the Fissipedia, while the Inadaptive Creodonts have reached an equal grade of specialization in enamel structure as in other respects.

4. *Borhyæna* is more highly developed than any modern marsupials, equalling the modern Carnivora in its enamel specialization. Whether this applies to the other Sparassodonta with less specialized dentition is not known.

The above conclusions harmonize very readily with the evidence from the morphology of the teeth, skull, and skeleton in the Carnivorous Marsupials, Creodonts, and modern Carnivora. They are certainly not in accord with Dr. Lydekker's view that the Marsupials are derived from Creodonts. The highly developed enamel structure of *Borhyæna* may be best interpreted as meaning that certain of the South American pseudo-Carnivora were more progressive and specialized in the histology of their teeth than any of the modern Australian pseudo-Carnivora, as they certainly are in many other features of their osteology and dental evolution, in each case paralleling (for obvious mechanical reasons) the Placental Carnivora. The loss of epipubic bones and of palatal vacuities might also be expected as a consequence of their more progressive character, while their marsupial derivation and relationship is attested by practically all the remaining characters distinctive of the order.

As regards the position of the Creodonts, the writer has had the opportunity during the last three years of studying a collection far more extensive and complete than has ever been known before, and hopes shortly to publish the results of these studies. It is sufficient to say at present that the evidence is entirely in accord with the conclusions derivable from the valuable data on the histology of the teeth given by Mr. Tomes; that the Creodonts were nearly related to the modern Carnivora, and show no considerable approach to the Marsupials; that the Inadaptive Creodonts (Creodonta of Wortman and Lydekker) are not intermediate between Carnivora and Marsupials, but parallel the modern Carnivora, specializing earlier than the Adaptive group (included in Carnivora by Wortman), which latter approximates the Marsupials to a limited extent by retention of several primitive characters. These conclusions have been maintained in recent years, and the antiquity of the division between Marsupials and Placentals emphasized especially by Osborn, Scott, and the writer in this country, and by most European authorities; the additional evidence confirms them throughout.

III.—SEDGWICK MUSEUM NOTES.

THE BASE OF THE SILURIAN NEAR HAVERFORDWEST.

By F. R. COWPER REED, M.A., F.G.S.

ON several previous occasions[1] the author has described in the pages of the GEOLOGICAL MAGAZINE certain fossils from so-called "Slade Beds" from the roadside near St. Martin's Cemetery, Haverfordwest.

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[1] Reed: GEOL. MAG., Dec. V, Vol. II, 1905, pp. 98, 100, 103, Pl. IV, Figs. 8–12; ibid., pp. 447, 448, 449, 451, 453, Pl. XXIII, Figs. 3, 4–7, 9, 16; ibid., pp. 493, 494, 497, 498, 500, Pl. XXIV, Figs. 1–10, 14, 15; ibid., Vol. III, 1906, p. 361.

A large collection of fossils has been made by Mr. V. M. Turnbull from this particular locality during the last few years and presented to the Sedgwick Museum. From a prolonged study of this material and comparison with the typical fauna of the Slade Beds as described by Messrs. Marr & Roberts, the conclusion has been forced upon me that we have here to deal with a higher palæontological horizon than the true Upper Bala of this district, and that there is much more reason for putting it in the Silurian than for keeping it in the Ordovician. The stratigraphical evidence which has subsequently become available is in support of this view. A list of the fossils from this bed may be useful at the present moment, particularly as the Sedgwick Museum possesses by far the most extensive series which has been collected from it (see opposite page, 537).

The rock in which they occur is a greenish-grey, fine-grained, argillaceous mudstone with occasionally minute specks of mica and a little arenaceous material, but usually of a very uniform smooth texture. It breaks in an irregular, often subconchoidal manner, and is devoid of any regular or well-marked planes of division. Exposed surfaces and the fossils themselves are generally more or less iron-stained. In appearance and general characters it is difficult or impossible to distinguish the rock from the higher beds of the Slade Series, but the fauna is completely different.

The mudstone lies above a series of unfossiliferous (?) black shales, and intercalated in the latter is found a persistent bed of sandstone or grit. This whole series of beds may be conveniently termed the "St. Martin's Beds," as a local designation seems necessary; and the fossiliferous mudstone in it may bear the name of the "St. Martin's Mudstone."

The true Ordovician occurs near Portfield House as a more micaceous mudstone lying fifty yards below the band of sandstone, according to Mr. Turnbull, and yielding *Trinucleus seticornis*, *Orthis biforata*, *Leptæna sericea*, etc. But until the whole succession has been worked out we may defer attempts at correlation, and a detailed comparison of the St. Martin's and associated beds with those of other areas is at present undesirable.

The occurrence of *Phacops mucronatus*, *Strophomena siluriana*, *Meristella* cf. *crassa*, and *Diplo*. cf. *modestus* are sufficient in themselves to show that we have here to deal, not with the highest Ashgillian, but with the base of the Silurian. The strongly marked palæontological break between the St. Martin's Mudstone and the Slade Beds proper seems abundantly to justify the drawing of the Silurian line below and not above them. All the typical Slade species are absent; no *Trinucleus* occurs, and the higher affinities of the fauna are indicated by the occurrence of certain species (*Cornulites scalariformis*, *Goniophora* cf. *cymbæformis*, *Meristella* cf. *crassa*, *Atrypa* cf. *flexuosa*, *Orthis* cf. *Edgelliana*, *Scenidium Lewisi*, *Crania Grayi* var., *Lingula Symondsi*, *Diplo*. cf. *modestus*) which are not known from undoubted Ordovician beds. The Llandovery Beds of the Gas Works have, on the other hand, a completely distinct fauna.

With the exception of the Brachiopods (especially the genus *Orthis*) the fauna of the St. Martin's Mudstone is poor; the Gasteropods, Cephalopods, and Graptolites are very rare, the two latter groups being represented only by two or three specimens in the whole collection. Lamellibranchs are numerous in peculiar species, but not in individuals. Trilobites are not common, but of them *Acidaspis* and *Phacops* occur most frequently.

[*Note.*—In the sequence given by Mr. Cantrill, his Beds 1, 2, 3, and 4 correspond to my "St. Martin's Beds"; see p. 538.]

LIST OF FOSSILS FROM THE ST. MARTIN'S MUDSTONE.

Phacops mucronatus, Brong.
Ph. sp.
Cyphaspis megalops, McCoy.
Acidaspis sladensis, Reed.
A. sp.
Lichas (*Corydocephalus*) sp.
L. cf. *laciniatus*, Dalm.?
Turrilepas sp.
Cornulites scalariformis, Vine.
Tentaculites sp.
Orthoceras cf. *gracile*, Portl.
Bellerophon cf. *acutus*, Sow.
Cyrtolites sp.
Hyolithes sp.
Pleurotomaria (*Clathrospira*) sp.
P. (*Liospira*) sp.
Holopella sp.
Modiolopsis Martini, Reed.
M. subgradata, Reed.
M. 2 sp. ind.
Whitella (?) *inutilis*, Reed.
Orthodesma semiradiata, Reed.
Goniophora cf. *cymbæformis*, Sow.
Arca Turnbulli, Reed.
Ctenodonta sladensis, Reed.
C. lingualis, Phill.
C. sp.
Meristella cf. *crassa*, Sow.
Atrypa imbricata, Sow. (cf. *flexuosa*, Marr & Nicholson).
Orthis elegantula, var.
O. cf. *Edgelliana*, Salt.
O. porcata, McCoy, var. *sladensis*, Reed.
O. vespertilio, Sow., var.?
O. aff. *Bouchardi*, Dav.
O. sp. ind.
Strophomena siluriana, Dav.
S. siluriana, var.
S. sp.
Leptæna rhomboidalis, Wilck.
Scenidium Lewisi, Dav.
Crania Grayi, Dav., var.
Orbiculoidea perrugata, McCoy.
Lingula Symondsi, Sow.
L. ovata, McCoy?
L. 2 sp. ind.
A new Cystidean.
Crinoid stem-joints.
'*Favosites*' *fibrosus*, Goldf.
Diplograptus cf. *modestus*, Lapw. (determined by Miss Elles).

IV.—Stratigraphical Note.[1]

By T. C. Cantrill, B.Sc. Lond., of the Geological Survey.

The fossils which Mr. V. M. Turnbull has collected from supposed Slade Beds on the "roadside near St. Martin's Cemetery, Haverfordwest," were obtained along the north side of a road leading westward from St. Martin's Cemetery to Portfield House, on the west side of the town. About half-way between the Cemetery and Portfield House the road is crossed by a by-road known as Jury Lane; one of the fossiliferous localities lies 110 yards east of Jury Lane crossing, another is 100 to 150 yards west of it. The area in question is contained in the Old Series one-inch Geological Survey map, Sheet 40, the New Series one-inch map, Sheet 228, and in the six-inch map, Pembrokeshire, Sheet 27 N.E.

So long ago as 1885 Messrs. Marr & Roberts[2] worked out the general structure of the district, and showed that the town of

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[1] Communicated by permission of the Director of H.M. Geological Survey.

[2] "The Lower Palæozoic Rocks of the Neighbourhood of Haverfordwest": Quart. Journ. Geol. Soc., vol. xli (1885), pp. 476–491.

Haverfordwest is situated on or near the junction of the Lower Llandovery Beds on the south with the Slade Beds of the local Upper Bala on the north. But without a complete and detailed survey of the ground it would have been hazardous to assign definitely any given locality in the neighbourhood of the junction to either Bala or Llandovery. Messrs. Marr & Roberts showed that at or near the base of the Llandovery there is a band of coarse conglomerate, succeeded by a grit; the former locally thins out altogether; the latter is less variable. The grit was described by them as exposed in a railway-cutting south of Shoalshook (north-east of Haverfordwest), but was not traced by them farther westward, into the immediate locality which has since yielded fossils to Mr. Turnbull.

The recent work—as yet unpublished—of the Geological Survey at Haverfordwest has enabled us to arrive at the following sequence :—

LOWER LLANDOVERY (part).	5. Green mudstones, fossiliferous, with thin grits and a group of sandstones. Haverfordwest gasworks.
	4. Green mudstones, softer and more shaly than 5, and comparatively barren. Railway-cuttings north-east of Haverfordwest Station.
	3. Shales, dark-grey and blue-black.
	2. Sandstone. North-east end of railway-cutting at Cethings.
	1. Shales, dark-grey and blue-black, with conglomerate sometimes present within them or at their base.
SLADE BEDS (Bala).	Fossiliferous mudstones.

The sandstone (No. 2) is the grit described by Messrs. Marr & Roberts as met with "in the railway-cutting south of Sholeshook" (op. cit., p. 484). To their description we are now able to add that from the railway the sandstone can be traced westward to St. Martin's Cemetery, which it traverses from end to end, and thence through the fields bounding the north side of the road which yielded Mr. Turnbull's fossils. As the beds dip steeply southward it follows that the fossil-bed in question is in the Llandovery and not in the Slade. A Brachiopod band a foot or so thick is present in the railway-cutting at Cethings at 30 feet above the top of the sandstone (No. 2 of table); it occurs at the junction of the dark shales (No. 3) with the overlying mudstones (No. 4), which for some feet above the junction are characterized by small dark blotches. Exactly the same sequence obtains at the fossiliferous localities discovered by Mr. Turnbull west of St. Martin's Cemetery: the sandstone yields débris in the hedges, and is followed on the south by black shales; these pass up where they reach the north side of the road into dark-green mudstones, which yielded the fossils, while the blotched mudstones are exposed on the south side of the road close by. The beds strike along the road, so that all the fossils are referable to approximately one and the same horizon, which I estimate to lie about 250 feet above the base of the Lower Llandovery.

Perhaps one of the most interesting fossils Mr. Turnbull has obtained from the St. Martin's Cemetery localities is a graptolite which Miss G. L. Elles identifies as *Diplograptus modestus*, a characteristic Lower Birkhill form common in the *Diplograptus vesiculosus* zone in the Moffat district of Scotland.

V.—FURTHER NOTES ON THE ARTHROPODA OF THE BRITISH COAL-MEASURES.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

FOR some years past a Committee of Littleborough and Rochdale geologists, consisting of Messrs. W. H. Sutcliffe, Walter Baldwin, W. A. Parker, S. S. Platt, and others, have devoted themselves to the task of working out the beds of shale containing clay-ironstone nodules, a portion of the Middle Coal-measures at Sparth Bottoms, half a mile south-west of Rochdale Town Hall, in beds estimated to occur 135 feet above the Royley Mine Coal-seam.

In the clay-ironstone nodules occur well-preserved ferns, *Calamites*, *Sigillariæ*, shells of *Carbonicola acuta* and other Coal-measure lamellibranchs, whilst the number of Arthropoda obtained is probably unsurpassed in any locality of this formation.[1]

The first Arthropod obtained from Sparth Bottoms was noticed by Mr. Walter Baldwin, F.G.S., under the name of *Prestwichia rotundata*, Prestw., sp. (Trans. Manch. Geol. Soc., vol. xxvii, part 6, 1901, pp. 149–155, with a plate); the second in 1903, by the same geologist, who identified it as *Bellinurus bellulus*, König (op. cit., vol. xxviii, part 8, pp. 198–202). The third and most important discovery was made by Mr. W. A. Parker, F.G.S., namely, a new species of fossil Scorpion, which was described and figured in 1904 by Messrs. Baldwin & Sutcliffe under the name of *Eoscorpius Sparthensis* (Quart. Journ. Geol. Soc., vol. lx, p. 396, fig. 2). These geologists have continued their researches, of which a brief account was given by me at the York Meeting of the British Association (1906). Many subsequent finds have been most obligingly confided to me by these gentlemen, and through the kindness of Mr. W. H. Sutcliffe the specimens figured have since been presented to the Geological Department of the British Museum (Natural History), the only condition imposed being that they should be described. I am endeavouring gradually to carry out this part of the agreement.

Previously (GEOL. MAG., 1905, Dec. V, Vol. II, pp. 433–444) I had described and figured various forms, namely: *Anthrapalæmon serratus*, H. Woodw., sp. nov. (op. cit., pp. 438–439, Figs. 1, 2); *Euphoberia Brownii*, H. Woodw. (Fig. 3); and *Xylobius moniliformis*, H. Woodw., sp. nov. (op. cit., pp. 442–443, Fig. 4). In that paper I also gave a summary of several other Arthropods discovered and described from the Lancashire Coal-measures up to that date (1905).

In June last I figured and described two new species of *Eurypterus* from the Coal-measures of Derbyshire[2] (GEOL. MAG., 1907, pp. 277–282, Pl. XIII); and in September I gave a description of the brood-plates, or marsupium, lately discovered in several examples (evidently the females) of *Pygocephalus*, a primitive Schizopod Crustacean (op. cit., 1907, pp. 400–407, Pl. XVIII), which was first obtained in 1857 from the Glasgow Coalfield, afterwards from near Manchester, later from Dudley,[3] and finally from Sparth, Rochdale.

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[1] Abstract British Association Reports, York Meeting, 1906, Section C (Geology).

[2] Discovered by Dr. L. Moysey, M.A., of Nottingham.

[3] Discovered by Mr. Herbert W. Hughes, Assoc. R.S.M., F.G.S., of Dudley.

1. Bellinurus Baldwini, sp. nov.

Amongst other interesting fossils from this last-named locality is a small king-crab which I believe to be new and undescribed; the following brief description may serve for its identification.

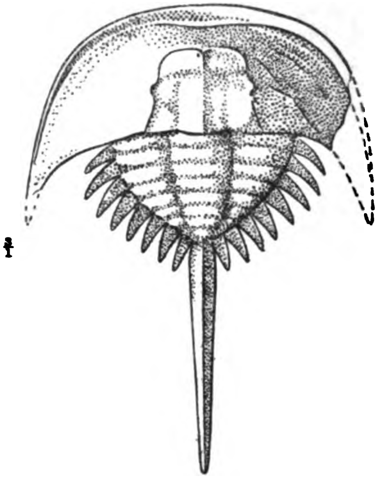

Fig. 1.—*Bellinurus Baldwini*, H. Woodw., sp. nov. Enlarged three times nat. size. Coal-measures: Sparth Bottoms, Sparth, near Rochdale. Presented by Mr. W. H. Sutcliffe, F.G.S., to the Geological Department of the British Museum (Natural History).

This small and nearly perfect king-crab has a widely expanded semicircular head-shield (prosoma), 2½ times as broad as it is deep, the genal or lateral portions of the shield being each as broad as the central portion (glabella); the lateral angles of the head-shield are produced posteriorly into stout, well-developed genal spines, the points of which extend as far back as the sixth post-cephalic segment of the opisthosoma. The head-shield, or prosoma, is depressed or flattened anteriorly, and has a broad, well-defined margin, widest in front, diminishing in breadth laterally, till it ends in the extremity of the cheek-spines. A clearly-defined raised line separates the glabella from the genal portions, but the cheeks are confluent in front of the glabella, which is enclosed by a raised line forming a double arch, one on either side of the median ridge; this is marked by a small V-shaped indent, on either side of which are placed the larval eyes (ocelli), while the compound eyes are seen midway on the lateral raised borders of the glabella, as is usually the case in most trilobites and in the living king-crab. The posterior border of the head-shield (prosoma) measures 15 mm. in breadth across its falcate cornua. The opisthosoma is much narrower; its broadest anterior segment which joins to the prosoma measures only 10 mm. across.

The opisthosoma is semicircular in outline, and is composed of eight distinctly trilobed segments, more or less anchylosed together, and diminishing in breadth from before backwards; the division line or boundary of the segments can be distinctly traced across the body, being terminated on either margin by a stout falcate spine 2 mm. in length and backwardly curved.

The telson or tail-spine is fairly stout, it is 9 mm. in length, and is strongly ridged down the centre.

This little king-crab approaches the forms described by Mr. W. H. Baily in 1863 from the Coal-measures, Queen's County, Ireland[1] (Ann. Mag. Nat. Hist., ser. III, vol. xi, p. 107, pl. v, fig. 1), but the carapace is more rounded and the genal spines are less sharply bent outwards away from the body; the opisthosoma is also less angular, and there are no tubercles on the median line of the body-segments; the marginal spines also in *B. Baldwini* are shorter, stouter, and stronger than in Mr. Baily's specimens. This is true also of the species *B. bellulus*, König, from Dudley, etc.[2]

In September last I named a new species of *Pygocephalus* from Sparth in honour of its discoverer, Mr. William Albert Parker, F.G.S., of Rochdale, one of the most enthusiastic of workers at the Sparth Beds. To-day I dedicate this *Limulus* to Mr. Walter Baldwin, who has described as well as assisted in finding many beautiful specimens from this locality.

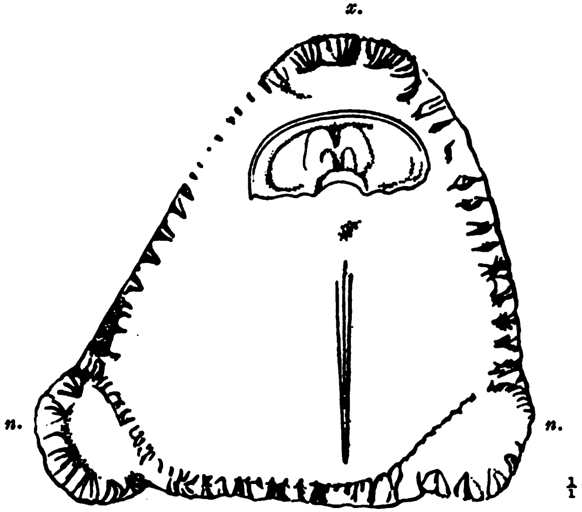

FIG. 2.—*Bellinurus longicaudatus*, H. Woodw., sp. nov. Nat. size. Coal-measures: Sparth, near Rochdale. Presented by Mr. W. H. Sutcliffe, F.G.S., to the Geological Department of the British Museum (Natural History), Cromwell Road.

2. BELLINURUS LONGICAUDATUS, sp. nov.

The king-crab (Fig. 2) to which I desire to call attention presents some points of unusual interest. It is enclosed in a rather large nodule of shale roughly triangular in shape, weighing 2 lbs. 2 oz., and measuring 4 inches across. This nodule has been successfully split open, and reveals upon its plane surfaces a long-tailed *Bellinurus*, lying in the centre of the transverse section of the walls and resting upon the surface of the node of a Calamite stem measuring 3 inches across, to its dark external border. The stem has been squeezed considerably out of its normal circular form into that of a nearly obtuse triangle, having two nodal buds, shown also in section at *n.*, *n.*, and traces of the woody tissue (xylem) may be observed along the margin at *x.*, while outside (not shown in Fig. 2) is a dark carbonaceous band, doubtless representing the outer layer of the stem with traces of the linear leaves of the Calamite.

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[1] H. Woodward, Brit. Foss. Crust., Merostomata: Pal. Soc. Mon., part v (1878), pl. xxxi, figs. 1, 2.

[2] Op. cit., pl. xxxi, figs. 3, 3*a*.

Plants are nearly everywhere associated in these beds with the remains of Arthropods, suggesting fresh-water conditions and always the close proximity of land. The following is a list received from Mr. Robert Kidston, F.R.S., a year ago, of fossil plants determined by him from the Middle Coal-measures, Sparth, at a horizon 40 yards above the Arley Mine and 40 yards below the Neddy Mine. He had not seen the above-noticed specimen, which was obtained subsequently to his examination of the plants from Sparth.

Dactylotheca plumosa, Artis, sp.
Mariopteris muricata, Schl., sp.
Alethopteris lonchitica, Schl., sp.
,, *valida*, Boulay.
Neuropteris impar, Weiss, sps.
Cyclopteris trichomanoides, Brongn.
Spiropteris sp.
Calamocladus equisetiformis, Schl., sps.
,, *charæformis*, Sternb., sps.
Sphenophyllum cimecifolium, Sthg., sps.
var. *saxifragæfolium*.
Lepidophyllum majus, Brongn.

Fossil of doubtful affinity:—

Vetacapsula Cooperi (Mackie & Crocker).

The following is a brief description of *Bellinurus longicaudatus*:—Breadth of head-shield, or prosoma, 23 mm.; length, 9 mm. Deeply emarginate at the neck-furrow. There is a strongly-marked raised rim around the prosoma, within which is a wide depressed border, which is continued round the latero-posterior margin of the cheeks to the nuchal furrow of the glabella. The glabella approaches nearly to the front border of the head-shield and has a raised border around it, forming a double arch in front with a V-shaped indentation on the median line, which is ridged down the centre; the neck-furrow is raised, strongly arched, and emarginated; the compound eyes occupy a rather backward position on the raised lateral border of the glabella; the genal portions of the shield are well-rounded without prominent cheek-spines at the postero-lateral angles; a raised rim having a flattened border extends around the margin of the cheeks to the neck-furrow. There are faint indications of neck-spines at the posterior angles of the glabella (not shown in the figure). The opisthosoma, which is very indistinct, was probably 8 mm. in length by 15 mm. in breadth, with a short spinose border to its segments; the telson measures 20 mm. in length, and is narrow and pointed.

This is a very well-marked Limuloid, although imperfectly preserved; the head-shield is broader in proportion to its length than is the case in most other species, and the cheeks are very rounded. It is to be hoped that other examples may be met with.

Dr. H. Dukinfield Scott, F.R.S., has figured a Calamite node from Sparth obtained by Mr. W. A. Parker, F.G.S., in 1891, in his "Studies in Fossil Botany," fig. 11, p. 35. Other figures will be found in Professor A. C. Seward's "Fossil Plants," vol. i, 1898: p. 310, fig. 73; p. 316, fig. 77, showing nodes and buds; p. 330, fig. 85 (linear leaves of a Calamite).

The above specimen was obtained by Messrs. W. H. Sutcliffe, F.G.S., and Mr. W. A. Parker, F.G.S., and presented to the British Museum (Natural History).

3. EOSCORPIUS (MAZONIA) WARDINGLEYI, H. Woodw., sp. nov.

Since the discovery by Mr. W. A. Parker, F.G.S., of the nearly perfect specimen of a fossil Scorpion in the Middle Coal-measures at Sparth Bottoms, Lancashire (described and figured by Messrs. Walter Baldwin and W. H. Sutcliffe, F.G.S., in 1904; see Quart. Journ. Geol. Soc., vol. lx, pp. 394–399, figs. 2, 3), another less perfect example belonging to a distinct species has been forwarded to me for examination. It presents upon the two split surfaces of an irregularly fractured clay-ironstone nodule the impression and counterpart of an imperfect head-shield, with some of the limbs and five of the præ-abdominal segments attached; the post-abdomen is not preserved. In front of the head-shield the two chelicerae (*f.*) are seen, and one of the pedipalps (*p.*) or maxillary palpi on the right side and a detached portion of the other on the opposite side[1]; also parts of three or more of the imperfectly preserved ambulatory legs (*l.*, *l.*), which appear to have had only a simple single claw (*not claws*) at their extremities.

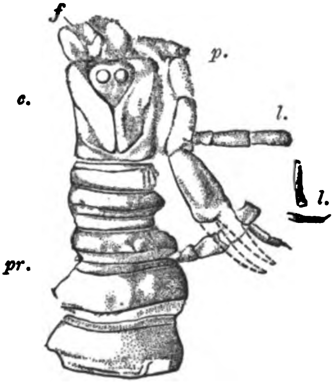

FIG. 3.—*Eoscorpius* (*Mazonia*) *Wardingleyi*, H. Woodw., sp. nov. Magnified one-third nat. size. Middle Coal-measures: Sparth Bottoms, Lancashire. *f.* cheliceræ; *p.* pedipalpi; *l.*, *l.* ambulatory legs; *c.* cephalon, head; *pr.* præ-abdomen. (Only five of the seven præ-abdominal segments are preserved on the split surface of the nodule.)

The eyes, which are rather close together, are round and prominent, with their lenses directed forwards; they are placed near the centre

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[1] Accidentally omitted in figure.

of the head-shield, occupying a raised, heart-shaped area encircled by a depression, outside which is a rounded, raised, laterally encircling border divided posteriorly down the centre line by a narrow groove. The hinder border of the head is narrower and more angular than the anterior, which is slightly rounded. Each segment of the præ-abdomen has a narrow raised ridge along both its anterior and posterior border, and there is evidence of a thinner and more membranous wrinkled integument uniting the stouter chitinous dorsal plates of the several segments together. The two most anterior body-rings are narrower than the hinder segments, and were perhaps ornamented by one or two tubercles upon their surface, in addition to the two raised ridges already mentioned on the anterior and posterior border.

Breadth of head-shield in front, 8 mm.; behind, 7 mm.; length, 10 mm.
Length of cheliceræ, 24 mm.; of walking-legs, 21 mm.
Breadth of orbital prominence, 5 mm.
Breadth of the 1st segment of the præ-abdomen, 9[1] mm.; length, 2 mm.
" 2nd " " 8[1] " " 3 "
" 3rd " " 10[1] " " 5 "
" 4th " " 13 " " 6 "
" 5th " " 14 " " 6 "

The form which most closely resembles this scorpion from Sparth (but which unfortunately is also imperfect) was made known by Messrs. Meek & Worthen in 1868, from the Carboniferous formation of Mazon Creek, Illinois, U.S.A. (see Geol. Surv. Illinois, vol. iii, pp. 563–565, figs. A–D), under the name of *Mazonia Woodiana*. It has since been figured in many works, and another example has been described from the Carboniferous series of Joggins, Nova Scotia (see Scudder, Phil. Trans., 1882, p. 650). It has been relegated by Scudder and other subsequent writers to the genus *Eoscorpius* (see Peach, 1882, Thorell, 1885, and Scudder, "Fossil Insects, Myriopods, and Arachnids," Washington, 1891, United States Geological Survey, pp. 25 and 27). Professor Dr. Anton Fritsch, of Prague, in his recent work ("Palaeozoische Arachniden," Prag, 1904, p. 77), refigures it under the old name of *Mazonia Woodiana*, M. & W., fig. 96 in text, but mentions that Scudder in Zittel (Eastman's edition) had adopted *Eoscorpius* as the generic name. *Mazonia* had been represented in the figure as having nine segments in its præ-abdomen, but that most probably was an error due to some obscurity in its preservation or to the duplication of the folds of the integument already referred to, which may have looked like additional segments. We may rely fully upon Mr. S. H. Scudder's determination that only seven segments are really present in the præ-abdomen of *Mazonia*, and as our specimen has only the five anterior segments preserved we need not discuss this point more fully.

There is sufficient distinctive character in the Sparth specimen, when compared with *Mazonia*, to justify us in giving it a specific name, and I gladly comply with the desire of my friend Mr. W. H. Sutcliffe to identify it as *Eoscorpius* (*Mazonia*) *Wardingleyi*, after Mr. Charles Wardingley, F.G.S., of Edinburgh, who carried on excellent geological work in the neighbourhood of Rochdale some years ago.

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[1] The true breadth of the 1st, 2nd, and 3rd segments is uncertain, as a part of the left side is buried in the matrix, and the nodule resists development.

The specimen has been presented by the discoverers to the Geological Department of the British Museum (Natural History).

4. Geralinura (?) Sutcliffei, H. Woodw., sp. nov.

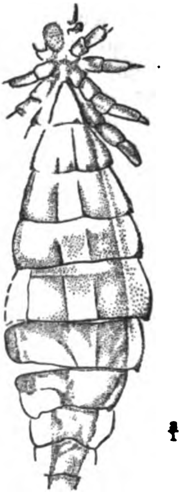

Fig. 4.—*Geralinura Sutcliffei*, H. Woodw., sp. nov. × 3 times nat. size. From the Middle Coal-measures: Sparth, near Rochdale. Original specimen presented to the Geological Department of the British Museum (Natural History).

Among the smaller forms of Arachnids from the Coal-measures the above Figure 4 represents one obtained a year ago from Sparth (enlarged thrice the natural size). The head-shield was either extremely small, or, as is more probably the case, it has been displaced, and we see only the centre of attachment for five pairs of short, stout, ambulatory limbs, whose bases were no doubt situate around or just behind the mouth. These walking-legs are seven-jointed, and terminate in a simple recurved claw. The falces and the palpi are not preserved. Behind the head succeed nine præ-abdominal segments, and a tenth, an extremely small narrow segment, which is no doubt the commencement of the post-abdomen. There are no traces of stigmata on any of the segments; the upper surface is therefore the only one seen upon the two halves of the little nodule. The head-shield is not seen.

1st segment	of the	præ-abdomen	3	mm. broad by	2	mm. long.
2nd	,,	,,	5	,,	2	,,
3rd	,,	,,	5½	,,	3	,,
4th	,,	,,	6	,,	3	,,
5th	,,	,,	7	,,	3	,,
6th	,,	,,	6	,,	2	,,
7th	,,	,,	6	,,	2	,,
8th	,,	,,	5	,,	2	,,
9th	,,	,,	4	,,	2	,,

'There is a tenth, extremely narrow, segment just on the edge of the nodule, which is probably the first post-abdominal segment.

'The first five segments behind the head are narrower in front and broader along their posterior border; but from the sixth to the ninth this is reversed, as they are broader in front and narrower posteriorly, giving to the body its general elliptical form. Each segment has a slightly raised transverse border and a narrow longitudinal ridge along the median line, and a similar lineation midway on either side; the lateral margins of each segment curve gently outwards, and the posterior angles are slightly produced and pointed backwards.

This fossil is no doubt related to Scudder's genus *Geralinura*, of which four species have been described from the Coal-measures of Bohemia, viz.: *Geralinura Bohemica*, Scudder; *G. crassa*, Kušta; *G. noctua*, Kušta; *G. Scudderi*, Kušta (see Professor A. Fritsch, "Palaeozoische Arachniden," 1904, pp. 61–62); and one, *G. carbonaria*, Sc., from the Coal-measures of Illinois.[1]

This genus is defined by Mr. Scudder as having the cephalothorax (prosoma) ovate, rounded in front, and narrower than the squarely truncated posterior border, with well-rounded sides, not more than half as large as the abdomen, which is cylindrical, sometimes depressed, and composed of nine principal segments, the first three being shorter than the others; and is followed by a post-abdomen of three *much contracted* joints, and this again by the jointed thread-like tail (peculiar to the Thelyphonides). There are a pair of eyes on the front of the cephalothorax. The palpi are large, robust, and coarsely chelate. The legs are moderately long and slender.[1]

Our specimen, although agreeing generally with the above description of the genus *Geralinura* in its body-segments, differs in the shortness of its limbs, whilst the palpi and the head are only imperfectly preserved, nor is the thread-like tail visible. But rather than create a new genus I have placed it provisionally under Scudder's genus *Geralinura*, and dedicate the species to my friend Mr. W. H. Sutcliffe, F.G.S., of Shore Mills, Littleborough, who has liberally presented this and so many other choice specimens to the British Museum.

5. ANTHRACOMARTUS, Karsch: Zeitsch. deutsch. geol. Gesellsch., 1882, p. 560.

The following is Scudder's diagnosis of the genus:—The cephalothorax (prosoma) is quadrate, the front square, or scarcely convex, half the size of the abdomen (opisthosoma); the coxæ laterally affixed, radiating from a broad triangular sternal plate, the base of which forms the posterior margin. Sides of the body showing a distinct though slight constriction between the prosoma and the opisthosoma, the latter being more convex. Opisthosoma orbicular, a little longer than broad, composed of *seven* segments.

Of this genus Scudder writes: "This is apparently the most abundant type of Arachnida in the Carboniferous formation. Kušta has noticed four species in Bohemia alone; one is found in Bavaria, one in Silesia, and at least two in our own coal." If we follow Professor Fritsch's classification and include, under the Anthracomartidæ, *Anthracomartus*, *Brachypyge*, *Anthracosiro*, *Eotrogulus*, and *Vratislavia*, we should have to record fourteen species in this very widely distributed Carboniferous family of Opiliones.

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[1] See S. H. Scudder, "Illustrations of the Carboniferous Arachnida of North America of the Orders Anthracomarti and Pedipalpi," May 7th, 1890, pp. 454–456, pl. xxxix, figs. 1, 3, 4: Mem. Boston Soc. Nat. Hist., vol. iv, No. 9, Boston, 1890.

1. The first recognised form of British fossil Arachnids of the order Opiliones was described by me in 1871 (see GEOL. MAG., Vol. VIII, pp. 385–388, Pl. XI) under the name of *Eophrynus Prestvici*, Buckl., sp. This was originally noticed by Buckland in 1836, from a less perfect specimen, in his "Bridgewater Treatise," who referred it "to the family Curculionidæ, of which the diamond beetle is a familiar example." He adds: "the abdominal rings are very distinct. I shall designate this insect by the provisional name of *Curculioides Prestvicii*" (Buckland, vol. ii, 1836, pp. 76–77, pl. 46, fig. 2; fig. 1 op. cit. has not been identified). Locality, Coalbrook Dale.

2. The second was figured and described in the GEOLOGICAL MAGAZINE for 1872 (pp. 385–387, Pl. IX, Figs. 1, 2) under the name of *Architarbus subovalis*, H. Woodw., from the Coal-measures of Lancashire, an Arachnide with an elongated form of body. It measures only 16 mm. in length and 7 mm. in greatest breadth, but is more evenly oval in form than is *Geralinura Sutcliffei*, which is more nearly elliptical in outline (see Fig. 4 of this paper).

3. The fragmentary remains of an Arthropod figured and described by J. W. Salter in 1863 as *Eurypterus mammatus*, Salter, from the Coal-measures of Pendleton, Manchester (see Quart. Journ. Geol. Soc., vol. xix, p. 84; and GEOL. MAG., 1873, p. 105, Figs. 1, 2), are still known only from portions of body-segments, but there is little doubt in my own mind that they are parts of a large Arachnide. They agree closely with similar Arthropod remains described and figured by Jordan[1] under the name of *Arthropleura armata*, Jordan.

Similar specimens have come into my hands from the Coal-measures of Fifeshire, collected by Mr. J. W. Kirkby, F.G.S.; from the Coal-measures of Radstock, Somerset, collected by Mr. J. McMurtrie, F.G.S.; and from the Coal-measures near Manchester by Professor Sollas. To these I hope to refer again shortly.

4. Mr. R. I. Pocock has contributed so largely to our knowledge of the recent Arachnida that one is not surprised at his interest also in fossil forms (see his paper on *Eophrynus* and allied Carboniferous Arachnida in the GEOLOGICAL MAGAZINE, 1902, pp. 439–448 and 487–493, with figures of *Eophrynus*, *Brachypyge*, and *Anthracomartus*, pp. 490–491).

5. In 1903 Mr. Pocock continued his researches and described a new Carboniferous Arachnid, *Anthracosiro Woodwardi*, gen. et sp. nov., GEOL. MAG., 1903, pp. 247–251, Figs. A, B.

6. He described a second species of *Anthracosiro* (*A. Fritschi*, sp. nov., op. cit., 1903, pp. 405–408).

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[1] See *Palæontographica*, Bd. iv (1856), Taf. ii, Figs. 4, 5, from the Coal-measures of Saarbruck, Rhenish Prussia. See also Pal. Soc. Mon. Merostomata, pt. iv (1872), pp. 163–168.

A table of the orders of Arachnida (after Fritsch) will be found in the Geological Magazine for 1904 (pp. 472–474), which will give a general notion of the fossil forms, of which 39 genera and 67 species are recorded:—

37	Carboniferous and Permo-Carboniferous	from	Bohemia.
6	Carboniferous	from	Silesia.
1	,,	,,	Dresden Museum.
1	,,	,,	Bavaria.
2	,,	,,	France.
1	,,	,,	Belgium.
1	,,	,,	Scotland.
5	,,	,,	England.
1	,,	,,	South Wales.
1	,,	,,	Arkansas, U.S. America.
7	,,	,,	Illinois, U.S. America.

To these we may add:—

1	Scorpion	from the U.	Silurian	of Gotland.
2	,,	,,	,,	Scotland.
1	,,	,,	,,	N. America.

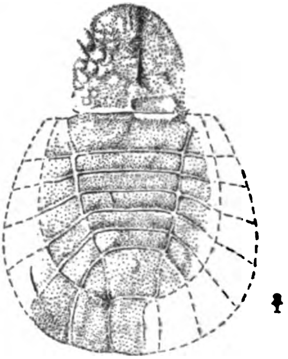

Fig. 5.—*Anthracomartus trilobitus*, Scudder, 1884. Proc. Amer. Acad. Arts and Sci., vol. xx, p. 17; Comptes rend. soc. ent. Belg. (3), No. 62 (1885), p. 85, fig.; Mem. Boston Soc. Nat. Hist., vol. iv, No. 9 (Boston, 1890), p. 451, pl. xxxix, figs. 7–10. Middle Coal-measures: Sparth, near Rochdale, Lancashire. Presented to the Geological Department of the British Museum (Natural History) by Mr. W. H. Sutcliffe, F.G.S.

The specimen from Sparth, like so many other examples of this widely distributed type, displays only the dorsal or tergal aspect of an imperfectly preserved prosoma and a nearly complete opisthosoma of an *Anthracomartus*, which has none of the appendages preserved, and the split nodule containing the impression has but a fragmentary counterpart which assists but little to eke out a description of the other and larger half. The specimen is 24 mm. in length by 15 mm. in breadth. Of this the prosoma is 8 mm. in length and *about* 8 mm. in breadth; the opisthosoma is 17 mm. long by 15 mm. across the widest part, but the margin of the body is more or less broken (see Fig. 5). The opisthosoma shows a median dorsal region which is 8 mm. broad just behind the prosoma, and diminishes in breadth to-

3½ mm. at the distal border; from this median region a series of diverging radial marginal plates forms a double row around the dorsal region, both rows having a rounded external margin which runs somewhat parallel at first but gradually widens posteriorly from the anterior margin to the terminal central plate. The horizontal lines of separation between the plates is strongly marked, very straight, and parallel upon the dorsal region of the opisthosoma, but the vertical lines converge from the neck-segment to the seventh segment, which is narrowest and bears a smooth rounded tubercle upon its centre, corresponding to the anal ring upon the sternal aspect of the body. The surface of the opisthosoma is finely granulated. The first segment is nearly twice the length of the second, which is narrowest; the third, fourth, fifth, and sixth segments are nearly equal in length; the seventh is more than twice the length of the preceding one, being even longer than the first segment; the eighth in line is not probably a true segment, but a post-anal plate, and corresponds to the 'telson' or tail-plate of *Limulus* and *Eurypterus*.

I do not propose to make a new species upon this very interesting little Arachnid, but prefer to refer it to Scudder's species of *Anthracomartus trilobitus* from the Carboniferous formation of Fayetteville, Arkansas, United States, with the description and figures of which it most closely agrees (see Scudder, Carb. Arachnida N. America, May, 1890, pp. 451–452, pl. xxxix, figs. 7–10: Mem. Boston Soc. Nat. Hist., vol. iv, No. 9, Sept., 1890, Boston, U.S.).

VI.—NOTES ON SOME COASTAL FEATURES IN CO. WATERFORD.

III. TRAMORE BAY TO DUNMORE EAST.

By F. R. COWPER REED, M.A., F.G.S.

THE projecting mass of land between Tramore Bay and the mouth of the River Suir consists of Old Red Sandstone, and the cliffs are mostly high, bold, and precipitous. The valleys which descend to the sea are more or less filled with Boulder-clay and other drift materials, testifying to their pre-Glacial excavation. The geological history of these valleys and of the large shallow lagoon lying inside the long spit of sand dunes which nearly cuts off the head of Tramore Bay deserves a separate article, and we will therefore here commence with the description of the eastern shore of this bay stretching from Summerville to Brownstown Head. Messrs. Wright & Muff[1] in their paper on the pre-Glacial shore-line of the South of Ireland made no reference to this portion of the Waterford coast.

The cliff below Summerville House is composed of the usual type of Boulder-clay of the district, but devoid of any large boulders; it is capped by 4–8 inches of whitish to yellow marl without any stones; above this comes 1–2 feet of wind-blown sand immediately beneath the thin soil. The Boulder-clay here is only about 6 feet thick, and the total height of the cliffs is only 8–12 feet. The line of these drift-formed cliffs recedes inland behind the large triangular area of grass-grown hummocky land which projects seawards at Bass Point; this area represents a comparatively recent accumulation of sand which has been built outwards for some 200 yards from the base of the cliffs so as to narrow the channel of Rinnashark Harbour leading into the Back Strand lagoon.

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[1] Scient. Proc. Roy. Dublin Soc., vol. x, pt. 2 (1904), pp. 250–324.

Outside the mouth of the harbour the base of the drift cliffs is washed by the sea at high tide, and their height has increased to over 20 feet. Their lower 10–20 feet are here composed of wind-blown false-bedded sand, and on this rests 2–3 feet of yellow Boulder-clay. A layer of drift sand 1 foot thick rests on the latter, and then come the subsoil and soil. This succession can be traced for about 75–100 yards along the shore, but the thick lower sands then die out, and a dark greyish clay, 4–8 feet thick, comes in beneath the Boulder-clay; it is full of small angular fragments of black slate, and in some places rests directly on the Old Red Sandstone, but in others on very coarse 'head' composed of large angular or subangular fragments of the Old Red conglomerates, flags, and sandstones of the locality. This head must undoubtedly be correlated with Messrs. Wright & Muff's Lower Head, and is of strictly local origin; it reposes directly at this spot on the smoothed pre-Glacial platform which has been cut across the alternating succession of hard and soft beds of the Old Red Sandstone.

Portions of the rock-platform, more or less dissected by recent marine erosion, can be observed under the cliffs, and it does not appear that it was in the first instance planed down to a uniform level surface. Its average height above present high-water mark is 3–4 feet, but in places, owing to its uneven surface, it is as much as 10 feet.

As for the pre-Glacial cliff, it is obvious that it does not run quite parallel to the present coastline; and it seems to lie a little distance inland, being indicated by an abrupt change in the declivity of the hillside, and frequently also by a line of small scars at the top of the nearly horizontal shelf or terrace of drift which extends outwards as a distinct feature of varying width along much of the eastern side of Rinnashark Harbour to end abruptly in the present cliffs of drift, 30–40 feet high. Post-Glacial erosion has not as yet been sufficient here to cut back the drift deposits as far as the old cliff.

The Boulder-clay (of the usual type) increases in thickness as we proceed southwards along the coast, and attains a thickness of 20 feet in the cliffs. Here and there above it we meet with patches or pockets of what may be regarded as the representative of the Upper Head in the shape of a deposit of small angular or subangular fragments of Old Red Sandstone closely packed together, and with a thickness of about 2–3 feet. But usually the sole deposit above the Boulder-clay is blown sand of recent date.

Outside Rinnashark Harbour the pre-Glacial cliff curves out westwards so as to meet the present sea-margin, and the drift deposits are then seen banked up against the solid Old Red Sandstone, which from this point onwards forms the modern cliffs. Except in a few sheltered spots or original coves the pre-Glacial cliff has been cut away by recent erosion on this exposed bit of coast; but here and there for nearly a mile southwards, i.e., as far south as the cove named Cooneenclogher, traces of it may be met with. The Lower Head with the old beach-deposits below it are occasionally extremely well exposed in these spots. The patches of the beach-deposits measure from 1–2½ feet in thickness, and consist of bedded shingle and sea-sand arranged in definite layers, well-rolled pebbles of the usual ellipsoidal shape in a matrix of fine sand forming the basal bed. The pebbles appear to be entirely of local origin, and are mostly rounded fragments from the Old Red conglomerates. A few such well-rounded pebbles can generally be found at the base of the coarse Lower Head in cases where definite beach-deposits are absent. The Lower Head itself is extremely coarse, and consists of huge blocks of the Old Red Sandstone series of the cliffs, mostly of irregular angular shape, but some with rounded corners. Tabular masses of the sandstones or flags, shapeless blocks of the conglomerates, with smaller fragments of the same, and a little fine red sand compose the deposit, which frequently possesses a thickness of 12–14 feet. The large component blocks lie at all angles, and are often as much as 3–4 feet long.

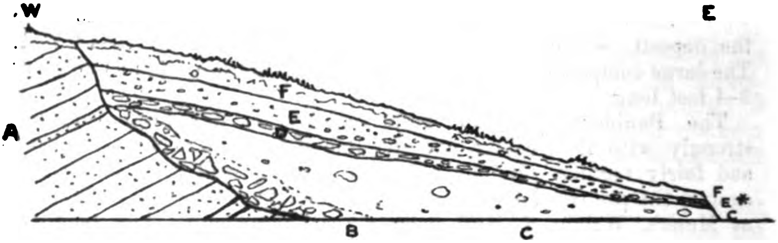
The Boulder-clay which rests directly on this head contrasts strongly with it in colour, and the line of junction is clearly marked and fairly regular. In one place the head is well seen banked up against the pre-Glacial cliff, which is worn and rounded off at the top, as Messrs. Wright & Muff have noticed elsewhere. The Boulder-clay here overlaps the head and comes to rest directly on the solid rock, the head merely filling up the angle at the base of the cliff. It is remarkable that no disturbance of the loose materials of the head seems to have taken place when the Boulder-clay was deposited; the glaciation cannot have been intense at this point.

Rathmoylan Cove.

The section in this locality is chiefly interesting from the clear development and coarse nature of the Upper Head at the mouth of a small pre-Glacial valley. This valley runs down to Rathmoylan Cove, and is more or less filled with drift deposits. The present stream has cut down into them to some extent so as to form small cliffs 4–5 feet high along the lower part of its course, but the rocky floor of the pre-Glacial valley must be sought at some depth below the modern beach-level where the stream now enters the sea. The cove is shut in on the east and west sides by walls of solid Old Red Sandstone, and is in reality the flooded lower end of the old valley, from the mouth of which marine erosion has removed the soft beds of drift which are now exposed only in the cliff forming the head of the cove.

This cliff rises from nearly beach-level by the road leading down to the strand to the top of the bounding ridge on the west, giving a cross-section of one side of the valley. Small landslips, rainwash, and vegetation obscure the actual face of the upper part of the pre-Glacial slope, but the steeply-sloping rocky side is well seen nearer the base of the cliff. Resting directly upon it we find a deposit which must undoubtedly be correlated with the Lower Head. This bed has a thickness of 3–4 feet, conforms to the solid rock-slope on which it reposes, and disappears with it below the present beach-level a few yards out from the western angle of the beach. It is composed of purely local materials derived from the immediately adjacent beds of the Old Red Sandstone flanking the valley; the fragments are not sorted according to size, but are roughly arranged in layers, and, though the larger ones (some are 2–3 feet long) are angular, the smaller ones, consisting of the soft red sandstone of the cliffs, are more or less rounded, and there are intermixed a few small rounded quartz pebbles similar to those in the neighbouring conglomerates.

SECTION OF DRIFT AT HEAD OF RATHMOYLAN COVE.



A. Old Red Sandstone.
B. Lower Head. 3–4 feet.
C. Boulder-clay. 6 feet.
D. Upper Head. 1 foot.
E. Sandy shingle, 1½–2 feet thick, thinning eastwards and replaced by clay at E*.
F. Subsoil and soil.

Resting on this head, but not as clearly marked off from it as usual, is a reddish Boulder-clay containing many small rounded pebbles mostly of quartz or of the Old Red conglomerates, with comparatively few large or angular fragments. These few, however, are frequently glaciated and scratched, and in addition to boulders of the immediately local rocks there are others of a more distant origin; thus, there are angular fragments of a greyish felsite showing beautiful fluxion structure and banding, and there are well-rounded boulders and pebbles of a fine-grained whitish quartzite. Less common are subangular small slabs and chips of black slate, more or less rounded boulders of a greenish felsitic ash or felsite, and much weathered and honeycombed pieces of Carboniferous Limestone. The total maximum thickness of the Boulder-clay here seen is about 6 feet, and it appears to thin out against the valley side and to overlap the Lower Head in the other direction.

Above this Boulder-clay comes a regular but unusually coarse deposit which must be correlated with the Upper Head. It is 1 foot thick and consists of closely-packed and irregularly bedded angular slabs and blocks of the local sandstones of the Old Red identical with those of the present sea-cliffs. These are intermixed with a few fragments of the conglomerates, some of which are rounded, and there are a few non-local rocks like those in the underlying Boulder-clay. There is scarcely any fine matrix to the bed. The red sandstone fragments average 4–6 inches in length, and often have their angles rounded off, but towards the cliff they increase in size, number, and angularity, attaining a length of 1–1½ feet. The slabs mostly lie flat, being arranged in a decidedly parallel manner so as to give to the bed the appearance of stratification, but there is no sorting according to size, except in the horizontal manner above mentioned. This deposit is very distinct and definitely marked off from the other beds. It dips at a much lower angle to the valley-floor than the rocky slope on which the Lower Head rests, and follows the slope and contour of the present ground, as seen by the edge of the cliff of drift in which it is exposed. At about 20 yards from the western corner of the beach it loses its distinctive characters, thinning out and merging into an overlying bed of sandy shingle. This bed of sandy shingle is a regular deposit, 1½–2 feet thick, consisting of small well-rounded pebbles and sub-angular fragments of the Old Red rocks, of fairly uniform size and roughly bedded in sand; it overlaps the Upper Head eastwards in the cliff section, itself then thinning out and being replaced by a sandy bed without stones 6 inches to 1 foot thick and resting directly on the Boulder-clay. The materials of which this bed of shingle and sand are composed bear the obvious marks of arrangement and deposition by running water. Resting upon this bed come a clayey subsoil and soil, in all about 2 feet thick, almost devoid of rocky fragments and pebbles.

Just as in the section at Fornaght Strand (Geol. Mag., Dec. V, Vol. IV, 1907, p. 17), we find here deposits of water-borne materials combined with the subaerial and coastal accumulations of pre-Glacial, Glacial, and post-Glacial times.

The Boulder-clay of this portion of the coast does not contain the large masses of granites, gneisses, and metamorphic rocks which we have described near Passage (ibid., p 501). Most of its non-local rocks might have been derived from the weathered débris of the neighbouring Old Red Sandstone conglomerates, which contain a most varied assortment of rocks. The greater part of the shingle of the existing beach appears to have been derived from this source. But the fragments of Carboniferous Limestone must have been brought from the country to the north by the ice or some other transporting agent; and there is so far no reason for thinking that the Boulder-clay here was the product of any ice-sheet but that from inland. There is no evidence that the Irish Sea ice touched the coast in this part, and no flints or marine shells have been found in any of the beds of drift.

The relations of the present and ancient watercourses and of the inland topography to the movements indicated by the coastal features are still under examination, and promise to throw considerable light on the later stages in the geological history of the country.

NOTICES OF MEMOIRS.

DESERT CONDITIONS AND THE ORIGIN OF THE BRITISH TRIAS.[1]

By J. LOMAS, A.R.C.S., F.G.S.

(*Concluded from the November Number, page* 514.)

THE occurrence of salt lakes in deserts is of the greatest interest and importance in the quest we have set before us. They are so characteristic of arid regions that it is essential we should have a clear impression of their peculiarities if we wish to make a true comparison with the rocks of the Trias. They have been described so frequently by travellers that I need only quote one or two examples.

Munzinger,[2] in the "Narrative of a Journey through the Afar Country," describes the great salt basin to the east of the Abyssinian mountains as bordered with walls of gypsum. Further he writes: "The first part of the salt basin is sandy, but after a short distance clay appears on the top, and every now and then we found a rain-ditch with powdered salt in it. After 1½ hours march we found a line of potasse trees, otherwise no tree or bush. The soil by degrees becomes of a greyish tint, and further on resembles a frosted ploughed field; but at the end the bed of salt becomes more thick and hard and presents the appearance of a lake frozen over."

Captain C. G. Rawling,[3] in exploring Central Tibet, visited numerous salt lakes. Of Gore Tso he writes: "A fine lake was seen two miles to the east, but mounds of some white mineral, piled up along the banks, almost certainly indicated that the water was undrinkable. Although this was the 5th of July, the lake was frozen from end to end. . . . On the following morning I made my way to the shores of the lake and found . . . all around rose a solid ridge of salt deposit, three to four feet high and from thirty to forty feet wide. No vegetation grew within 500 yards of the shores, while to the north a barren plain stretched away for many miles. The lake is about 20 square miles in area."

Sven Hedin, writing of the Takla Makan desert, states that the dunes are arranged in a sort of network pattern with hollows—or bayirs—inside the meshes. Clay rises as oblong terraces or steps four to five feet high along the slopes, giving the appearance of beach lines. The bottom of the bayir is covered with a granular hard incrustation of salt, at a distance resembling rime. Upon digging eight or nine inches a thick deposit of pure salt is reached, evidently filling the bed of a desiccated salt lake, the margins and side terraces of which are coated with perfectly horizontal layers of yellowish-red clay eight to nine inches thick and hard as stone. In some bayirs a part remains moist, and is edged all round with a narrow belt of salt. A bed of gypsum was observed in some cases, and one contained the skeleton of a water bird and a dead day-fly.

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[1] Proc. Liverpool Geol. Soc., vol. x, pt. 3, 1907, pp. 172–180; slightly abridged.

[2] Geog. Journal, 1869, p. 200.

[3] "The Great Plateau," p. 61.

The above excerpts give one a good idea of what the desert salt lakes are like, and one or two facts common to all are worth noting. First, we have the clay bottom sometimes augmented in thickness by layers of sand which have drifted into the pool; then we note the constant association of salt and gypsum in the deposits. It is well known that concentrated brine precipitates the sulphate of lime out of solution. Further, we have no mention of carbonate of lime as one of the constituents left after evaporation, or, at least, if present it is not in sufficient quantity to call for special notice. Yet in the waters flowing from the hills towards the lakes this substance, as the bicarbonate of lime, must have been present, and probably exceeding the others in amount. The explanation is simple. The bicarbonate is chemically not a stable compound, and readily parts with the excess of carbonic acid. Hence, in passing over or through the soils the carbonate of lime will be precipitated and form the nodules and limestones described above, while the more chemically stable compounds will reach the lakes undiminished in quantity.

So it happens, as we should expect, that carbonate of lime segregates on the land, while salt and gypsum are the chief substances left as residues in the desiccated pools. Dolomite in perfect rhombohedral crystals is occasionally found in association with the products of desert pools.

Drifting sands blowing over the plains may fill up the hollows and leave no sign on the surface of the pools which formerly existed there. The lake deposits would still be there buried under the sand, and if a section could be made through them we should find beds composed mainly of sand with thin bands of clay following the limits of the lake and irregularly disposed at various horizons. On the margins the clay would show desiccation cracks and ripple-marks, the footprints of animals, and the remains of such forms of life as find a suitable habitat under such conditions.

Mr. T. H. Holland,[1] referring to the deposits in the Rajputana Desert, states that silt beds occur, filling in hollows in the Archæan surface. They have a general plano-convex lens shape, and are charged with salt, beds of gypsum, and concretionary nodules of carbonate of lime.

In our Triassic rocks we get the exact counterpart of these filled-in desert lakes. Bands of clay occur in all the divisions, but they are more common in the higher beds. When the full extent of the clay bands can be determined, they are always half lenses in shape, with the convexity downwards. It is on the lower surfaces of the sandstones, immediately resting on the clay, that we find casts of footprints, raindrops, ripple-marks, and desiccation cracks, and the clays often either contain pseudomorphs of rock-salt or deposits of this mineral and gypsum overlie the clay. The salt beds of Cheshire have these associations, and are now generally regarded as resulting from dried-up pools or lakes. Even when beds of pure salt are absent it is found that water from the Keuper Marls is almost invariably strongly impregnated with salt. It may be that where beds of pure salt are found they have been covered by drifting sand after complete desiccation of the pool, and when the salt is intimately mixed with the rock the wind-borne material was deposited in the pool while some water remained.

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[1] Brit. Assoc. Report, 1906, p. 575.

Dr. Cullis has recently described the occurrence of dolomite crystals in the Keuper Marls of the West of England. So far they have not been found in our locality, although carefully looked for.[1] We cannot say at present how these crystals have been formed, but their presence in recent deserts and in the Triassic rocks is of interest.

When dealing with the subterranean water supply of the desert it was pointed out that the impermeable bands which confine the water below show very striking differences of level. If these bands of clay can be regarded as the silt covering the floors of filled-up pools our difficulties are most satisfactorily met. (See p. 512.)

Thus far we have dealt with the part water plays in the economy of the desert. The waste of sand stretching as far as the eye can reach gives little sigu of the activities below the surface, and it is chiefly there that water has its work to do.

Surface Deposits.—We turn now to discuss the surface deposits themselves. It must not be supposed that even in the so-called sandy deserts the surface is uniformly covered with loose fragmentary materials. In the Algerian Sahara probably less than one-third is covered with sand. Solid rock forms the floor of vast barren plains, or stands as islands or cliffs washed by great seas of sand. However, it is mainly with the sand (and in this term we may for convenience include pebbles) that we have to deal.

Origin of the Sand.—The sands of the deserts were naturally at first attributed to marine action, and the presence of salt deposits no doubt gave verisimilitude to the idea that they represented dried-up sea-bottoms. Zittel, Tissandier, and others have shown that the fragmental material is of subaerial origin, and has been derived by the action of the ordinary disintegrating forces at work on the land.

In a climate such as ours it is hard to appreciate the importance of one of the most active disintegrating agents in the desert. One needs to stand under the tropical sun and in the presence of the riven rocks to fully appreciate what sun-flaking means. Unprotected by vegetation or covering soils the bare rocks become intensely heated during the day; when the sun's heat is withdrawn they rapidly chill by radiation, and thus by alternate expansion and contraction even the most compact and resistant rocks yield. A characteristic form assumed by sun-flaked rocks is the spheroid, and one is reminded of the spheroidal weathering often seen in basalt. In a cuboidal mass of granite the solid angles are the first to split, and then the edges go, and so flake after flake is removed until the block resembles a well-worn boulder. The flakes are usually from half an inch to a little more than an inch in thickness, but their horizontal extent may be many yards. After flaking, the smooth curved surfaces give one the impression of *roches moutonnées* when viewed at a distance, and individual spheroids resting on these surfaces resemble perched blocks. At the foot of a cliff screes of angular flakes tend to accumulate. These still further break up under similar influences and finally form sand. They may accumulate until the rock is buried under its own fragments, or in the rainy season the loose material may be carried away to form sandy deltas, and the surface of the solid rock may be kept open for further flaking. Sands resulting from the disintegration of granite and other rocks in the desert are in striking contrast to those formed in our own country in so much as chemical action takes no part in the breaking down of the rock. The fragments are chemically unaltered, and the flaked surfaces consist of perfectly fresh minerals. Of course, in the neighbourhood of mountains sufficiently high and conveniently situated to intercept moisture-laden winds, both chemical and mechanical disintegration may take place and streams may flow into the lowlands, mingling water-borne material with that of desert origin.

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[1] It might be noted that dolomite occurs in plenty in the sands dredged from the Mersey bar.

It is difficult to apply the tests of sun-flaking and the characteristics of desert sand to our Triassic deposits, as so few places exist where they are seen to lie on the rocks which gave them their origin. However, in the neighbourhood of Leicester, in Charnwood Forest, on Mount Sorrel at Croft, and at other places where the Keuper rests on the igneous rocks we get the very best conditions for making the comparison. Professor W. W. Watts has shown that in this district the Keuper fills up hollows in the older rocks, and denudation is now uncovering the old pre-Triassic landscape. The older rocks, particularly at Mount Sorrel, present curved flaked surfaces exactly like those described from the desert. Loose blocks are flaked into spheroids and lie tumbled in the Keuper Marls, which must have been accumulating at the time the blocks fell from the cliffs above. Screes of angular flakes rest against the ancient slopes, and the sand is composed almost exclusively of material from the adjacent rocks. Moreover, the surfaces of the rock, the scree material, and the sand are all chemically fresh.

The absence of decomposition products is well seen, too, in the Keuper sandstones of our own neighbourhood in places where infiltration has not taken place. When a clay band occurs in a rock face, the felspars in the top portion are usually kaolinised by the percolation of surface waters, but below the impervious layer they are remarkably fresh. This conclusively demonstrates that when they were laid down they were not subject to chemical changes.

Work of the Wind.—During the dry season the wind does its own work in carrying, sifting, rounding, and etching.

(1) *Carrying.*—In open ground driven sand tends to accumulate in ridge-shaped masses, the long crests lying transversely to the wind. When a dune of this kind has been originated the wind blows grains up the exposed slope and over the summit, where they drop on the leeside. The slope to windward is gentle, and on the leeside steeper and slightly concave. The concavity is due to a backward eddy which sets in as the wind passes over the crest, and can easily be demonstrated in our local sand-hills by putting a piece of paper or any light object against the leeward slope when a stiff wind is blowing. The paper will be seen to move up the slope against the wind.

In our neighbourhood the dunes seldom exceed 50 feet in height, but in the desert they have been measured up to 350 feet. A favourite simile with travellers is to compare dunes with the waves of the sea, with crest and trough following each other parallel in sequence or arranged in a network pattern.

One fundamental difference must be kept in mind; in the sea the wave motion progresses while the material is stationary. In the desert the sand travels with the wave movement. The Arabs say that the dunes 'walk.' It follows, then, that if the material goes forward the country to windward will be left bare unless fresh material is forthcoming from that quarter. Deposits accumulated by wind action show very characteristic false bedding. The nature of this depends on the steepness of the slope over which the sand tumbles and the varying directions of the wind. When the slope to leeward is very steep the weight of the sand at the top may cause the sand to slide down into the hollow, thus puckering and folding the layers beneath.

The distance to which sand may be carried by wind is very great. Dust-storms are sometimes met with in the Mid-Atlantic which can only have come from the western Sahara. At Las Palmas a ridge of sand dunes exists on the low isthmus connecting the Port with Isleta. The rocks of the island could not yield such a deposit, and captains of ships attribute the sand to winds blowing from the African continent. The finest sand dust may be carried in the air for hundreds of miles, and when the winds are constant the result will be the building up of thick masses of stratified material. Such is the origin attributed to the Loess of China, which attains more than a thousand feet in thickness, and Richthofen supposes it to have come from the desert areas of Asia. Professor N. S. Shaler[1] assigns a similar origin to the accumulation of fine-grained detritus in the Western Mississippi Valley, and he states that it has been derived from the Cordilleras.

(2) *Sifting.*—The sifting action of wind may be observed in a dusty road or in our local sand-hills. In deserts, however, where the winds blow more consistently from one quarter, the action is more perfect.

In a series of samples taken in the Sahara from the same locality in vertical sequence by the late Dr. Isaac Roberts the grains differ in size at each horizon, but for the same depth the sifting is so perfect that it looks as if each sample had been put through a sieve. Many other observers have commented on the sifting action of wind, and it is only reasonable to suppose that the size of a grain carried along will vary with the velocity of the current which moves it. Sven Hedin graphically describes a sand-storm he encountered in Central Asia. Near the ground the wind velocity was 40½ miles an hour. Six feet from the ground it measured 58½ miles an hour. Branches, tufts of grass, and grains as big as peas whirled in the air and struck his face with stinging force. A strong wind such as that described will move large and small particles alike, but as it loses velocity the particles will drop to the ground as the carrying power of the wind diminishes. Thus the sands raised by one storm will be graded horizontally, gradually getting smaller to leeward. The same sands may be worked up again and again by currents of differing velocities, and hence we should not expect to find the layers of even-sized grains to persist over very great distances. Again, the grains are not all composed of materials having the same relative density. Although quartz predominates, we find mica, felspar, magnetite, zircon, and other minerals, and each will be affected according to its linear dimensions and specific gravity.

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[1] U.S. Geol. Survey, 12th Report.

If we consider two particles of different sizes and having the same terminal velocities when falling under gravity we find the resistance varies as the square of the linear dimensions, and the weight jointly as the cube of the linear dimensions and the specific gravity. This is only a very simple and incomplete way of stating a very complicated problem, but it is possible to find in terms of their relative densities and dimensions the sizes of the different kinds of grains which will come to rest together.

We have already seen that where temporary streams flow down from high grounds fans of gravel are produced where they debouch into the plain, and along the beds of watercourses there exist layers of gravel, composed of water-worn stones. The distance these stones have travelled from their place of origin depends on the character and volume of the stream which brought them. It may be reckoned in miles or scores of miles. We pictured above (p. 511) the character of the deposits formed by the successive excavation and filling up of river valleys, and gave instances where sands with bands of pebbles intercalated at various horizons had resulted from this action. What is the effect of winds blowing over a deposit of this nature? The sands are carried by the air currents and form dunes, but the larger stones are too heavy to be moved and form a loose pavement on the desert floor.

According to Mr. H. T. Ferrar, of the Geological Survey of Egypt, these pebble layers may be so thin that the tread of a camel may break through and send up puffs of the sand from below at every step. At other times they are more than 100 feet thick. These may result either from excessive rainfall and strong currents of water or from the successive accumulation of materials brought down by streams through many wet seasons, and the removal of the finer material during many dry seasons. In any case, we have in deserts great spreads of gravel brought down by rivers and reassorted by wind action.

(3) *Rounding and Etching.*—Sands caught up by the wind and hurled against each other have a greater velocity and hence a greater impact than those carried along by moving water. In river and sea sands rounding does take place, but it does not approach the perfection seen in sands which have been subject to prolonged movement in air. The constant battering of grains against each other not only results in rounding, but in the production of excessively fine splinters of sand. It is this sand dust which is carried to great distances by winds and tends to accumulate on the lee sides of desert regions. Particles too heavy to be lifted bodily in the air are rolled along the ground. If it happens that the length of

a grain is great as compared with the width the rolling may be confined to one axis of revolution and a cylindrical form results. Cylindrical grains of this nature are not uncommon in desert sands, and they are found in the dunes round our coasts. The sands rolling up a slope often form the most exquisite ripples, giving the appearance of tiny dunes riding on the larger ones. Perfect spheres do not, as a rule, result from the attrition of very small grains, and we seldom find 'Millet seed' sands with a diameter of less than ·5 mm. Not only does abrasion take place by the striking of one grain against another, but the battering of grains against the solid rocks or against loose stones lying on the surface of the desert results in some characteristic effects. The effects produced on the rocks will vary not only with their hardness and texture, but also with the angle at which the impact takes place.

A glass tumbler dropped by a tourist in the desert was found after a time to be frosted and opaque on those parts exposed above the sand. It exactly resembled the sand-blast labels on our reagent bottles and the designs frosted on glass intended for ornamental purposes.

Blocks of obsidian found in the deserts of Iceland likewise become frosted on their exposed surfaces. Granite on the other hand takes a beautiful polish. If the rocks contain minerals of varying hardness the softer constituents tend to form hollows, while the harder materials stand out and are sometimes completely disengaged from the mass. In this way the fossils in the nummulitic limestone of which the Great Pyramid is built stand out from the surface, and large numbers of loose nummulites can be found in the sands surrounding the base of the pyramid. So perfectly and so intimately does the sand pick out the parts of superior hardness, or of looser texture, that pieces of silicified wood can be found in the neighbourhood of Cairo with the vascular fibres standing out from the less compact parenchymatous tissue.

Mr. W. D. Brown[1] recently described before the Liverpool Geological Society some most interesting experiments which he performed with artificial sand blast on various rocks. He showed that a blast with a pressure of 45 pounds to the square inch, acting perpendicularly on sandstone, drilled a cylindrical hole and removed 435 grains in 5 minutes, whereas the same blast acting on the same piece of rock at an angle of 45 degrees produced an even plane surface and only removed 400 grains in 10 minutes. A piece of granite with an oblique blast lost 200 grains in 5 minutes, while limestone lost 323 grains in the same time and under similar conditions. All the stones subjected to the experiments possessed rounded surfaces before being acted upon, but the sandstone and limestone were reduced to plane surfaces while the granite showed differential action, the quartz standing out from the softer constituents.

The production of a plane surface by oblique sandblasting may be compared with the action of a file drawn over a curved surface. Being rigid, the file moves in a straight line, it does not accommodate itself to the outlines of the substance, but produces a sharp cut edge where it leaves the object. Similarly, sand moving with great velocity keeps its initial path, while similar particles moved slowly by a current of water over a curved surface would roll over the leeward slopes and abrade during their descent. It must not be concluded that a plane surface can only be produced by the action of wind-driven sand. In Switzerland I have seen plane surfaces and sharp cut edges, produced in the beds of torrents carrying sand in suspension, quite indistinguishable from those produced by wind action. The plane surface then is largely a result of high velocity, and while this is of rare occurrence in currents of water it is common in currents of air.

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[1] Proc. Liverpool Geol. Soc., vol. x, p. 130.

When driven sand strikes a stone in the open desert it is deflected upwards and round the sides so that plane surfaces are formed on three planes. This is the typical form to which the name 'dreikanter' has been applied, and the finding of these in any deposit is regarded as one of the surest indications of wind action.

Sand blowing over a flat surface of rock tends to widen joints and open them out into a funnel shape, with the wide end facing the direction of the wind. The sides of the opened joints, too, are almost invariably undercut.

It has been shown by Professor Watts, Mr. Walcot Gibson, and others that the surface of the country had been carved by denuding forces into valleys and hills before the Trias was deposited. The newer rocks, by filling in the low grounds, smoothed down the landscapes, and in some places hills were completely covered. In no part of Britain do Triassic rocks attain a greater altitude than 800 to 900 feet above sea-level at the present day, and we have no proof that they ever extend much above this level. They are essentially deposits of the lowlands. Their distribution has been admirably summarised by Professor Bonney,[1] and I can add nothing to his lucid description of their occurrence. He shows that there exist two foci of coarse fragmental rocks, one in the western and northern Midlands and the other in Devonshire. No one now doubts that Professor Bonney is right in claiming these coarse deposits as of fluviatile origin. At the places mentioned, rivers reached the plains (whence they came does not matter at present) bringing down pebbles, well worn in transit, and no doubt a large amount of finer material as well.

Taken as a whole the deposits get finer as we go away from the foci, and on the extreme borders of the areas covered by Trias they consist of exceedingly minute fragments. At a subsequent stage in the history of the Trias, pebbles occur again, indicating a return to the conditions under which the lower beds containing pebbles were formed.

Assuming that desert conditions prevailed during Triassic time—interrupted, perhaps, by pluvial periods, when rapid streams brought down the pebbly constituents—let us see how far they show evidence of the action of wind. Except in the finer deposits such as the Keuper Marl true bedding is almost entirely absent. Current bedding there is in plenty, and frequently very steep—too steep, indeed, for the angle of rest of sand laid down in water. In extreme cases of steep false bedding the sands are often contorted at the bottom of the basin as though the weight of the sands above had caused a slide such as we have described as taking place in sand-hills.

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[1] "On the Origin of the Trias": Proc. Yorks. Geol. Soc., vol. xvi (1906), p. 1.

It is difficult to describe the structure of the sandstones; there are no geological terms exactly suitable. They have the appearance of a tumbled series of eroded lenticles. Anyone who has had the misfortune to map them knows how the beds thicken and thin out promiscuously, and how difficult it is to find a datum-line which will be of service in correlation. Even our late member and founder, Mr. Morton, whose knowledge of our local rocks was so intimate and extensive, would never give an opinion as to the horizon of a piece of Trias sandstone from a hand specimen. The only approaches to satisfactory datum-lines we possess are the two horizons where pebbles occur, and even these are only of service locally, as they are limited in extent. In sections cut through dunes in the desert between Ismailia and Kasassin I have seen beds very much resembling those I have attempted to describe above.

The marginal beds of the Trias area are almost without exception the Keuper Marls. They are found also covering the sandstones in the middle of the area, and sometimes they are intercalated with beds of sandstone. They are not strictly marls, but are composed almost exclusively of exceedingly fine and angular quartz dust. It has been suggested that they have been laid down in a lake, or a series of lakes, and the even bedding which they show is given as a proof. But bedding even more perfect may be seen in volcanic dust deposited on the land, and, further, Mr. T. O. Bosworth has shown that when the Keuper Marl rests against a sloping cliff the bedding slopes with the surface of the ground. This is quite unlike the conditions we should expect to find if it had been of subaqueous origin. Lakes of the desert type are found as local phenomena in the Keuper Marls, and have been referred to in a previous part of this paper. The marls may represent the smallest tailings of wind-carried material.

The sifting action of wind is everywhere evident in the Trias. Besides the horizontal grading already mentioned which characterizes the deposits broadly as a whole, we find that locally the same sifting influences have been at work. Sands of exactly the same dimensions occur as lenticular patches, a few feet or several yards in length. These are associated with other lenticles of larger or smaller grain, but in the same patch there is no admixture of large and small sizes. In our neighbourhood they are best seen at the top of the Bunter, immediately underlying the Keuper basement bed. The perfection of sifting into sizes shown at Bidston and at Scarth Hill is marvellous, but in other places and at other horizons the some features may be observed.

The concentration of pebbles from river deposits is also paralleled in the Trias. The pebble beds of the Midlands, although originally of fluviatile origin, do not exhibit the characteristics of river action. The individual pebbles show no orientation in the arrangement of their longer axes, but are wedged together in a tumbled mass as if they had dropped into their present situations by the removal of material about them. The insecurity of their positions is evidenced by the pitting which has resulted from their successive readjustments. The interspaces between the pebbles are almost free from sand, but lenticular seams of sand occur, which may have been protected from removal by wind, when the pebbles formed a continuous covering. There are places in our own district where it does not appear that concentration took place, and the sand with pebbles marking the situations of temporary streams still persist as originally laid down.

The occurrence of millet-seed sands in the Trias is too well known to need further comment, and they have always been attributed to wind action. Professor Watts,[1] too, has shown that the surfaces of the Mount Sorrel granite, when freshly uncovered from the mantle of Trias, show very characteristic wind etching, and at Croft the underlying igneous rocks have their joints widened and their vertical faces undercut in a way that could only be produced by wind. 'Dreikanter' occur sparingly in the pebble deposits. They are not common even in recent deserts, for only the surface pebbles can come under the influence of the wind.

This paper is not intended as a description of the Triassic rocks themselves, but to institute a comparison between the features and activities of existing deserts and the Trias rocks of our own country. The question has been discussed entirely from the physical standpoint. The palæontological aspect still remains to be considered. The animal and plant associations, and their adaptations to the peculiar circumstances under which they live in the desert, should find their counterparts in the Trias, if arid conditions existed during their formation.

REVIEWS.

I.—ROCK MINERALS. By Professor JOSEPH P. IDDINGS. (New York: Wiley & Sons, 1906.)

DURING the last ten years so many advances have been made in the microscopic study of minerals, and so many new species have been recognised among the minerals of rocks, that the need for a new textbook of the subject in the English language has been much felt. Professor Iddings' book is in some ways not unlike the well-known Rosenbusch Iddings', which has served the needs of several generations of students. It is really, however, a new work, as a very excellent introductory or general part has been provided in which the chemical, physical, and optical properties of minerals are described, while the second or descriptive part is entirely remodelled and brought up to date. It is not difficult to trace the influence of certain standard authors in the treatment of some parts of the subject; more especially that of Professor Groth in the chapters on optical properties, and of Professor Rosenbusch in the special descriptions of the minerals. But the book has a marked individuality owing to the bright and interesting manner in which the author has handled his materials. It is brief, but no doubt contains enough for the student's requirements. To say that it is the best work in the English language on this subject is unnecessary; it compares very favourably with any of the French or German manuals in current use. It will not obviate the use of the larger treatises, such as Rosenbusch-Wülfing, but will serve as an admirable introduction to them, and should find a place among the working manuals of every student of petrology.

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[1] Geological Journal, 1903.

Very few inaccuracies have come to our notice in reading the book. We may point out, however, that the Canada balsam on which rock slides are mounted has by no means a constant refractive index of 1·539; it varies somewhat, and is often 1·542 to 1·544, and this is of some importance in determining felspars, nepheline, etc. The student should be warned to test it for himself in slides containing quartz. The use of the selenite plate in determining the sign of axes and bisectrices of biaxial crystals should be given; it is much to be preferred to a mica plate, and is one of the most useful accessories to a petrological microscope. Some description of the method of measuring optic axial angles should certainly be provided; nowadays by means of a Schwartzmann's scale this is a very simple operation. Professor Iddings makes the very useful suggestion that the capital letters X, Y, and Z should be used to designate the three principal axes of the triaxial ellipsoid. We hope it will be generally adopted, as it will save a great deal of trouble in correcting printers' proofs.

In the tables at the end of the book the minerals are classed as isotropic, uniaxial, and biaxial, and given in groups arranged according to their refractive indices, a method which has many advantages to recommend it. The excellent coloured plate of interference colours, originally prepared by Lévy and Lacroix, is reproduced and will be greatly appreciated both by teachers and students.

II.—ROCKS OF THE CAPE COLVILLE PENINSULA, NEW ZEALAND. By Professor SOLLAS, with introduction and descriptive notes by ALEXANDER MCKAY, F.G.S.

THE Cape Colville Peninsula is part of the well-known Hauraki mining district, the source of large quantities of gold within the last forty years. It contains a great variety of igneous rocks, many of which are in advanced stages of decomposition and solfataric alteration. Many names had been applied to them by the miners, and it seemed necessary to get an authoritative classification; for that purpose about four hundred specimens were sent to Professor Sollas, who has written brief descriptions of them. A general account of the region is provided by Mr. McKay, who has apparently acted as editor of the volume. It is the first effort to treat of the petrography of this area as a whole. The book is illustrated by a large number of whole-page photomicrographs, which, while they are not all of equal excellence, often give a very clear idea of the structure of the rocks which are under description.

Volcanic action has gone on in this district in Palæozoic (Devonian and Carboniferous) and in Tertiary times. The igneous rocks are principally andesites of various types, dacites, rhyolites, and obsidians, but no well-characterised trachytes or basalts are present, though olivine occurs in some of the Tertiary andesites. Many of the andesites have a groundmass which appears to be pilotaxitic, but Professor Sollas has found that there is always in these rocks a matrix of quartz; the structure is really micropoikilitic. His observations on the isotropic material which replaces the felspar phenocrysts in certain modes of decomposition are very interesting. They had previously been described as fused or vitrified felspars. Many of the rocks are filled with secondary quartz or opal, sericite, and chlorite; in others there is much tridymite. Some of the andesites show fluxion brecciation; that which has been described as Wilsonite is probably of this nature, and in another case we have a hornblende hypersthene andesite in which the phenocrysts have been broken up and seem mylonised before the matrix had completely solidified. Another very interesting group of rocks is the spherulitic rhyolites of this region; some of them are well known to contain large spherulites with branching or 'cervicorn' processes, and excellent figures of these wonderful structures are given in these two volumes.

III.—GEOLOGY OF THE FEDERATED MALAY STATES.

GEOLOGIST'S REPORT OF PROGRESS. September, 1903–January, 1907. With rough sketch-map (topographical). By J. B. SCRIVENOR, Geologist F.M.S., formerly of H.M. Geological Survey of Great Britain. 8vo; pp. vi, 44. Printed at the F.M.S. Government Press, Kuala Lumpur. 1907. Price one dollar.

THE Government of the Federated Malay States are to be congratulated on having requisitioned the services of so capable and energetic an officer as Mr. J. B. Scrivenor to unravel the many intricate problems connected with the geological structure of that country. The geologist's work in these regions has been carried out under great difficulties, both on account of the want of good, serviceable topographical maps and because of the dense jungle which covers the country at high altitudes; nevertheless, the author gives us an excellent account of his three years' explorations. Some of the items of information have already appeared in "The Progress Report" for 1904, a notice of which has been published in the GEOLOGICAL MAGAZINE for 1906, pp. 40, 41, in association with another of the author's reports, "On the Geology of the Residency of Sarawak," etc.

The present Report is divided into two sections, viz. 'Structural' and 'Economical.' Under the former is described 'the Chert Series,' 'the Raub Series,' and 'the Tembeling Series.' The first of these, occurring at Tras, Raub, Lubok Plang, etc., contains Radiolaria, and may be analogous to the Culm of Devonshire or Sumatra; the next has yielded Carboniferous Cephalopods at Mill Gully and Goa, which have been determined by Mr. G. C. Crick, and remnants of a Permian fauna at Lubok Sukum, which favours correlation with the Upper *Productus*-limestone of the Salt Range, India; whilst the Tembeling Series is made to include a number of Triassic shells from Kuala Lipis, described some years since by Mr. R. Bullen Newton,[1] and

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[1] See GEOL. MAG., 1901, pp. 128, 189.

INDIA.		PAHANG. (*Federated Malay States.*)			MALAY ARCHIPELAGO.
UPPER GONDWANA.	*Jurassic.*	GRANITE with basic dykes.		*Jurassic.*	MIDDLE OOLITE OF SARAWAK. (*Limestone and marl.*) DOGGER OF W. BORNEO. (*Sandstone with some marl and limestone.*) LIAS OF W. BORNEO. (*Marl and clay slate with fine sandy beds.*)
	Trias.	TEMBELING SERIES. Conglomerate with pebbles of chert of the 'Chert Series,' sandstone, red and grey shales.	PAHANG VOLCANIC SERIES.	*Trias.*	ROTTI. W. BORNEO. *Clay slate, rarely calcareous, sandstone, banded, clouded and spotted siliceous beds, with Radiolaria.*
PRODUCTUS BEDS OF THE SALT RANGE.	*Permian.*	RAUB SERIES. Limestone, marl, calcareous shale, shale.		*Permian.*	TIMOR. *Limestone.* ROTTI. *Limestone.* *Supposed Palæozoic of W. Borneo.* TIMOR } ROTTI } *Sandy Limestone.* PADANG HIGHLANDS, W. SUMATRA. *Fusulina Limestone.*
	Carboniferous.			*Carboniferous.*	
		CHERT SERIES. Chert, with Radiolaria, light-coloured siliceous shale, carbonaceous shale with Radiolaria and abundant pyrite.			CULM OF SUMATRA?

fragments of a recently discovered fish which, according to Dr. A. S. Woodward, resembles *Semionotus*, a characteristic genus of the Trias formation. In the same series the author also places those interesting Phyllopod remains (*Estheriella*) which he obtained from the Semanggol Range, and which have been described by Professor T. Rupert Jones,[1] F.R.S., as of Trias age. Reference is also made to the author's discovery of fossils at Singapore, which were described by Mr. R. B. Newton and regarded by him as belonging to probably a Middle Jurassic horizon.[2] These particular fossils were found in an estuarine deposit, and consisted of marine mollusca (*Goniomya*, etc.) associated with plant-remains (*Podozamites*), an assemblage of forms resembling a facies peculiar to the Upper Gondwana Beds of India and other Eastern countries. Without actually placing the Singapore deposits in the Tembeling Series, the author acknowledges a similarity of structure with that group of beds.

The author then considers the mutual relations of the 'Chert,' 'Raub,' and 'Tembeling Series,' the chief points of which are set out in a table giving the probable equivalents of these deposits in India and various parts of the Malay Archipelago. So important is this table considered as a first attempt to correlate the formations of this area that we have ventured to reproduce it on the present occasion (p. 566).

The 'Economic' part of the report deals chiefly with the gold-mining industry and tin-mining. Gold, according to the author, "is not confined to any one rock in the Federated Malay States; but it is interesting to note that the greater part of the underground operations have been conducted in rocks of the Raub Series, and igneous rocks associated with them." Both alluvial and lode gold occur in the F.M. States, although scarcely worth developing under present circumstances. Should the jungle be cleared it is possible that the gold industry might be more successful. A great amount of information is given on the tin-lodes, including their occurrence, geological features, etc.

Throughout the report the author gives numerous references to the literature consulted.

R. B. N.

IV.—A GEOLOGICAL MAP OF ARMENIA AND ITS BORDER-RANGES, WITH INDICATIONS OF MINERALS AND MINERAL SPRINGS. Drawn and hand-coloured by FELIX OSWALD, D.Sc., F.G.S. One sheet (36 × 25 ins.); scale, 16 miles to one inch (1 : 1,013,760). With Explanatory Notes, 16 pp. London (Nottingham printed), 1907: Dulau & Co. Price 25*s.* net.

DR. OSWALD'S "Geology of Armenia," which we noticed in these columns but a few months ago, is now out of print and unattainable. This is the map to accompany the volume, and the little pamphlet issued with it gives a brief sketch of the matter contained in detail in the larger work. The map contains the new and important surveys made by the author between Trebizond and

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[1] GEOL. MAG., 1905, pp. 49–52, Pl. II.

[2] GEOL. MAG., 1906, pp. 487–496, Pl. XXV.

Lake Van, and includes the observations made by the following:—Abich, Ainsworth, Batsevich, Fournier, Frech, Hamilton, Koch, Loftus, Möller, Pohlig, Radde, Simonovich, Tchihatcheff, Tsulukidse, Wagner, and the 140 other persons mentioned by the author in his bibliography. The peaks and passes are indicated in the ranges, recent and extinct volcanoes, craters, mineral springs, whether hot or cold, and the minerals. The map is crowded with names, and ranges from the Caucasus on the north to the southern borders of Lake Urmi on the south, from the Euphrates on the west to the Caspian on the east. The coloration is well-done in transparent waterproof tints, and the production, in every way as remarkable as was the author's volume, will be of great value to geographers as well as to geologists.

C. D. S.

V.—GEOLOGICAL SURVEY OF ENGLAND AND WALES.

THE GEOLOGY OF THE COUNTRY AROUND HUNGERFORD AND NEWBURY.

By H. J. OSBORNE WHITE, F.G.S. pp. 150. 1907. Price 2*s*. 6*d*.

THIS memoir is an explanation of Sheet 267 of the New Series of the Geological Maps on the scale of one inch to the mile. The district with which it deals is situated mainly in South-Western Berkshire, but includes a part of Wiltshire and a very little bit of Hampshire. The only important towns are Hungerford and Newbury.

The solid geology is very simple—Chalk for the most part and clays and sands of the Eocene to a small extent—but the district is agricultural, and to the farmer the Drift is often of as much importance as the solid geology. This is so in the present case, for Drift of one sort or another covers a large portion of the surface, as an inspection of the map will show. The account of the Drift, too, occupies a considerable part of the memoir.

The solid geology is illustrated by an excellent horizontal section engraved upon the map. It illustrates the relative position of the various beds down to and including the Gault. That formation does not, however, come to the surface here, nor does there seem to be any record of a well or of a boring which has passed through it in this district. The Upper Greensand is consequently the oldest formation dealt with, but does not present features of any special interest. The Chalk is the important formation of the district, since it is found either at the surface or underlying Drift or Eocene beds over almost the whole area. Mr. Osborne White estimates that in this part of the country the thickness of the Chalk when most fully developed is about 700 feet. This, he adds, is a thickness not unusual in the Southern Midlands, but much less than that attained near the south and east coasts, where measurements of 1,000 and 1,300 feet have been recorded.

On the map the Chalk is divided into Upper Chalk, described by Mr. White as typically soft and white and containing many flints, with an estimated thickness of 400 feet; Middle Chalk, white to greyish-white, harder and less flinty, with a thickness of 120 feet at one place where it could be measured; Lower Chalk, greyish and marly, without flints, 120 to 150 feet or more. It is interesting to compare these figures with the record of the boring at Winkfield, near Windsor. There the thickness of the Chalk formation was found to be 725 feet, divided as follows: Upper Chalk, 337 feet; Middle Chalk, 169 feet; and Lower Chalk, 219 feet.[1]

The zones of the Chalk are not indicated upon the map, but they are fully dealt with in the memoir, and a sketch-map is given at p. 44 upon which the boundaries of the upper zones are marked. In Mr. Jukes-Browne's memoir on the Cretaceous Rocks of Britain, vol. iii, published in 1904, an account is given of the occurrence of the zones of *Marsupites* and of *Actinocamax quadratus* in the northern part of Hampshire (pp. 188–192), and, speaking of the latter zone, Mr. Jukes-Browne remarks that it appears to come in at certain places along the central part of the Chalk area between the anticlines of Winchester and Kingsclere. Probably, he adds, it only occurs in the form of outliers in the central part of the deeper synclinal troughs.

The present memoir deals with the district to the north of the Kingsclere anticline, and the author brings forward evidence tending to justify Mr. Jukes-Browne's inference, for he is able to record the occurrence of both the *Marsupites* and the *Actinocamax quadratus* zones, the latter in two places, in both cases in a shallow syncline. It should be added that much of this evidence had previously been published in a paper by Mr. Osborne White and Mr. Llewellyn Treacher, read before the Geological Society on April 25th, 1906 (Quart. Journ. Geol. Soc., vol. lxii, p. 499). Mr. White shows that the *Marsupites* zone, with its two sub-zones, the *Marsupites* band above and the *Uintacrinus* band below, is clearly recognisable in the Hungerford–Newbury district, but he states that the only places at which the zone is known to attain its full development at the outcrop are Kintbury, to the west of Newbury and Winterbourne, near Boxford, to the north-west of Newbury. He estimates the maximum thickness of the zone at 60 feet, i.e. about half that attained in East Kent and at Salisbury. The zone of *Actinocamax quadratus* has been recognised by the author in two small tracts, one on the spur of ground between Boxford and Winterbourne, and the other to the south of Kintbury. The thickness of the zone is 40 feet or more.

Mr. Osborne White devotes a chapter to the consideration of the structural relations of the Chalk and the Lower Eocene beds. The Eocene strata to the south of the River Kennet rest, as a rule, upon the Chalk of the *Marsupites* band, but are underlain by the *Actinocamax quadratus* beds near Kintbury, by the *Uintacrinus* beds to the south-west and south-east of Hungerford, and by the *Micraster cor-anguinum* chalk to the north-west of that town. North of the Kennet the Tertiaries are in contact with the *Uintacrinus* band over a small, irregular, and possibly discontinuous tract extending from the neighbourhood of Wickham south-eastwards at least as far as, and probably much farther than, Shaw, but lie directly upon some part of the upper half of the *Micraster cor-anguinum* beds everywhere else except in the little area west of Winterbourne, where the *Marsupites* and *Actinocamax quadratus* beds reappear in an outlier. Despite the occurrence of outlying patches of the *Act. quadratus* Chalk near Kintbury and Winterbourne, the tendency of the Eocene to overstep the higher zones of the Chalk towards the north is clearly recognisable. This northward overstep of the higher parts of the Chalk may, the author thinks, safely be attributed to an early Tertiary or pre-Tertiary planation, after the Chalk had received a gentle tilt approximately towards the south, and he considers that the northward overstep of the higher zones of the Chalk by the Eocene formation, which he has shown to exist in this district, is not merely a local phenomenon, but part of the transgression which cuts out the *Belemnitella mucronata* zone to the north of Salisbury and the greater part of the *Actinocamax quadratus* zone somewhere between that place and the crest of the Sydmonton range.

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[1] J. H. Blake & W. Whitaker, "The Water Supply of Berkshire": Mem. Geol. Surv., 1902, p. 95.

From the evidence before him the author infers that at or a little after the close of the Cretaceous period the tract, now the western half of the London Basin, formed part of the northern slope of an area of relative depression whose centre or axis lay far to the south, possibly on the site of the English Channel, and that before the deposition of the earliest Eocene sediments so far recognised in this region, the gently-inclined Chalk was subjected to a planation which bevelled off its higher zones in descending order towards the north, leaving here and there a troughed outlier such as that at Kintbury. The Eocene beds thus rest upon an eroded surface of Chalk, and the author considers that, at least, the ultimate shaping of this platform was the work of the sea. He describes the junction as even, or at most but slightly undulating, except, of course, where the Chalk has been indented by piping in more recent times. The top of the Chalk is often penetrated by tubular borings filled by material similar to that of the Eocene bottom bed. Similar borings in the top of the Chalk have been recorded in the adjoining districts, and have been variously referred to boring molluscs and to the roots of marine plants.[1]

The bottom bed of the Eocene consists of a few feet of dark-green or speckled greyish-green glauconitic loamy sand interbedded with seams of grey, greenish, or brown clay, often roughly laminated. Slightly worn or pitted flint nodules, with green coats and pebbles, and subangular chips of flint with the same external coloration are almost invariably present at the base, the nodules usually appearing in section as a single row at, or a few inches above, the top of the Chalk. Concretions of iron oxide, small granular aggregates of 'race,' and fine seams of chalky material are not uncommon in the same position, and in some places these and derived chalk fossils are abundant.

It is, we think, usually believed that the green-coated flints so frequently found at the bottom of Eocene beds where they rest upon Chalk are a part of the insoluble residue left by the underground decay of the top of the Chalk after the Eocene bed had been deposited, but whatever may be the case in other districts the evidence given above clearly shows that a different explanation of the presence of green-coated flints in the bottom bed is required here. The tubular borings in the surface of the Chalk and the chalky material in the bottom bed seem to show that no appreciable amount of dissolution of the Chalk surface has taken place since the deposition of the Eocene beds upon it.

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[1] See W. Whitaker, "Geology of the London Basin": Mem. Geol. Surv. (1872), p. 100. W. H. Hudleston, "Excursion to Reading": Proc. Geol. Assoc., vol. iv (1876), p. 521.

Banks of closely packed oyster-shells form a striking feature of the bottom bed in not a few sections, and the author records teeth of *Lamna* and a few marine shells. He infers that the bottom bed was deposited under shallow-water marine conditions. As elsewhere, the Reading Beds above the marine bottom bed consist of sands and mottled clays without shells, but leaf impressions have been observed at two places. They occur in seams of clay closely overlying the bottom bed, i.e. in a similar position to the Reading Leaf-bed. Mr. Starkie Gardner believed the mottled clays of the Reading Series to be a fresh-water deposit (Quart. Journ. Geol. Soc., vol. xxxix, p. 210), and we may probably regard all the beds in this district between the bottom bed of the Reading Series and the basement bed of the London Clay as of fresh-water origin.

The London Clay, as has long been known, thins westwards, and at the outlier west of Bedwyns in the south-western corner of the district it is stated to be only about 15 feet thick, whilst at Chisbury Camp at the northern end of the outlier there seems to be nothing between the Bagshot Beds and the Reading Series. Mr. Bennett thought that some greenish sand near Inkpen might belong to the Bracklesham Beds, but Mr. White gives reasons for doubting this, and consequently the highest Eocene formation in the district belongs to the sandy series, which in the London Basin intervenes between the London Clay and the Bracklesham. This formation is marked i^4 on the map, and is there termed "Bagshot Beds," whilst in the memoir it is described as "Lower Bagshot Beds." The similar beds at Bournemouth are on sheet 329 marked i^4, and termed "Bagshot Beds," whilst in Mr. Clement Reid's memoir on that sheet (1898) the formation is called "Bagshot Sands." We thus find the same formation with three different names, which seems needlessly to complicate matters.

After dealing with the Eocene formations, the author gives us a most interesting and original chapter upon the post-Bagshot disturbances and drainage features. At one time there was a fairly general idea that the sheets of gravel which cap the plateaux in the neighbourhood of the River Thames were a marine deposit, but in recent years the tendency amongst the workers in the geology of the South of England has been to look upon them as old river gravels, and the present author, Mr. Osborne White, considers that the drifts are local subaërial and fluviatile accumulations, which betray in their distribution a more or less obvious relation to, or dependence on, the larger (if not the smaller) elements of the existing physiography. As to the age of the drift deposits, he says that though some of them may be of Pliocene age, the bulk of them seem to belong to the Pleistocene and Recent periods, and many of them undoubtedly do so.

The beds of gravel of the district are separated upon the map into two divisions or classes—

(i) Plateau Gravel (of doubtful age and origin).
(ii) River and Valley Gravel.

Now, as the author explains, there may be some practical convenience in this division, though to a great extent it is a survival of the old theory of the marine origin of the plateau gravels. In any case, the result of the conclusion to which the author has come, and which has just been quoted, is that when he comes to speak of the plateau gravels he says: "The 'Plateau Gravel' group as defined on the sheet is, in a measure, an arbitrary one, for some of its members are not to be distinguished from deposits classed as 'River and Valley Gravel' by their composition, structure, mode of occurrence, or altitude, absolute or relative, that is to say, by any of the tests which are usually regarded as of chief importance for the discrimination of unfossiliferous, or very sparingly fossiliferous, drifts of this type, and further on he remarks that the Plateau and the Valley Gravels are very often inseparable; their more level spreads frequently appear to be but the higher and lower members of a single graduated series."

If it be admitted that the author is correct in his opinion, and we believe that he is here in agreement with many or most of his fellow-workers in the Thames district, then the history of our river system is thrown back to a vastly earlier date than could have been contemplated by those who looked upon the plateau gravels as of marine origin, and we find that the author is fully prepared to accept the result of his view, for he says that it seems not improbable that the broad outlines of the present drainage system were marked out in the Miocene period coincidently with the development of the Kingsclere fold. At the same time he considers it possible that the dominant surface slopes of the district, in so far as they have a tectonic origin, may be due less to Miocene folding than to Pliocene warping, and he also observes that the district may have been overflowed by the Diestian Sea, which, though not very probable, is no doubt a possibility for which we have to allow.

If we agree in the author's view as to the origin and antiquity of the gravels, the question of the age of the various deposits in relation to the age of the most recent earth-movements is one of great importance, for if earth-movement continued after the deposit of any part of the gravels the relative position and altitude of different gravel deposits may have been greatly affected thereby. The author, however, in suggesting a tentative grouping of the gravels, thinks it best to assume that the original height relations of the sheets of gravel have not been significantly changed by differential earth-movements.

He separated the plateau gravel into three stages—

(i) Cold Ash Stage gravel, now 265 feet above the present River Kennet, and possibly of late Pliocene age.
(ii) Bucklebury Stage, now 230 feet above the present river, possibly belonging to the earlier part of the Pleistocene period.
(iii) Silchester or Greenham Stage, 150–160 feet above the modern river of rather later date.

These gravels are more or less sandy and often well stratified, and the author distinguishes from them some examples of a much more argillaceous type of deposit, which he suggests may be of the nature of a mud-flow, generated by rapid thawing of frozen soil at or about the time of maximum glaciation of the country further to the north.

In the chapter on the valley gravel the author records several finds of implements at different places. The celebrated Knowle Farm pit is situated near Savernake in the south-west corner of the district. The implements from it are distinguished by a very peculiar varnish-like glaze, and Mr. Clement Reid, who described the locality, considered it to be contemporaneous with the Palæolithic deposits of Southampton Water, Bournemouth, and the Avon Valley. (Summary of Progress of the Geol. Survey for 1902, p. 208, 1903.)

The Alluvium of the River Kennet, with its deposit of fossiliferous fresh-water marl, is of great interest, and a good account of it is given with lists of the fossils. It is further dealt with in a valuable note by Messrs. A. S. Kennard and B. B. Woodward, which is printed as an appendix to the memoir.

Dr. W. Pollard and Mr. H. H. Thomas contribute another appendix on insoluble matter in samples of Upper Chalk, and the memoir concludes with a bibliography and an index.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

November 6th, 1907.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R. S., President, in the Chair.

The following communications were read:—

1. "On a Collection of Fossil Plants from South Africa." By Professor Albert Charles Seward, M.A., F.R.S., F.G.S.

The material on which this paper is based was, for the most part, collected by members of the Geological Survey in Cape Colony from the Molteno and Burghersdorp Beds. The Molteno Beds are placed at the base of the Upper Karroo, or Stormberg Series; the Burghersdorp Beds constitute the uppermost strata of the Middle Karroo, or Beaufort Series. Mr. A. L. Du Toit, who has contributed accounts of the stratigraphy of the plant-bearing and associated rocks, describes the occurrence of a transitional zone between the Molteno and the Burghersdorp Beds. The following species are described:—

(A) MOLTENO BEDS.

Schizoneura Carrerei, Zeill.
Schizoneura sp.
Thinnfeldia odontopteroides (Morr.).
Thinnfeldia sp.
Thinnfeldia, sp. nov.
Tæniopteris Carruthersi, Ten.-Woods.
Cladophlebis (*Todites*) *Rœsserti* (Presl).
Pterophyllum sp.
Baiera, sp. nov.

(B) BURGHERSDORP BEDS.

Schizoneura sp.
Thinnfeldia, sp. nov.
Tæniopteris Carruthersi, Ten.-Woods.
Danæopsis Hughesii, Feist.
Odontopteris, sp. nov.
Strobilites, sp. nov.
Pterophyllum sp., cf. *Pt. Tietzii*, Schenk.
Stigmatodendron, sp. nov.

A description is also given of *Schizoneura africana*, Feistmantel, a species originally figured by Hooker in an appendix to Bain's paper, published in 1845.

The additional plants recorded from the Molteno Beds afford further evidence in favour of assigning this member of the Stormberg Series to the Rhætic Period. While possessing certain Rhætic species, the Burghersdorp flora as a whole indicates a somewhat lower horizon.

2. "Permo-Carboniferous Plants from Vereeniging (South Africa)." By Professor Albert Charles Seward, M.A., F.R.S., F.G.S., and Thomas Nicholas Leslie, F.G.S.

The majority of the specimens described in this paper were obtained by Mr. Leslie from a sandstone quarry 1¼ miles from Vereeniging, on the banks of the Klip River; the sandstones are associated with shales, coal-seams, and glacial conglomerates. In the opinion of the authors, the plant-beds should be included in the Ecca Series (Lower Karroo). While recognizing certain well-marked differences between the *Glossopteris* floras and the Upper Carboniferous and Permian floras of the Northern hemisphere, they are inclined to think that there are more types common to the two botanical provinces than is generally supposed.

The following species have been recognized at Vereeniging:—

Schizoneura sp.
**Glossopteris angustifolia*, Brongn., var. nov.
Glossopteris angustifolia, Brongn.
Glossopteris Browniana, Brongn.
Glossopteris indica, Schimp.
Glossopteris sp., cf. *Gl. retifera*, Feist.
Gangomopteris cyclopteroides, Feist.
**Callipteridium* sp.
Neuropteridium validum, Feist.
Bothrodendron Leslii, Sew.
**Lepidodendron*, sp. nov.
**Lepidodendron Pedroanum* (Carr.).
Sigillaria Brardi, Brongn.
Psygmophyllum Kidstoni, Sew.
Cordaites (*Næggerathiopsis*) *Hislopi* (Bunb.).
Conites, sp.

Those marked with an asterisk are recorded for the first time.

3. "On the Structure and Relations of the Laurentian System of Canada." By Professor Frank Dawson Adams, D.Sc., F.R.S., F.G.S.[1]

This paper contains an outline of the results of the examination by Dr. Barlow and the author of an area of 4,200 square miles, comprised within the Haliburton and Bancroft sheets of the Ontario and Quebec series of maps. The paper opens with a short account of Logan's work in the original Laurentian area. The main conclusions reached by the author may be thus summarized:—(1) The Laurentian System of Sir William Logan consists of a very ancient series of sedimentary strata, largely limestones, invaded by great volumes of granite in the form of bathyliths; (2) this sedimentary series is one of the most important developments of the pre-Cambrian rocks in North America, it presents the greatest body of pre-Cambrian limestones on the continent, and it is best designated as the Grenville Series; (3) the invading masses of granite are of enormous extent; they possess a more or less distinct gneissose structure, due to the movements of the magma, which developed a fluidal and, in the later stages of intrusion, a protoclastic structure in the rock; (4) the granite gneiss of the bathyliths not only arched up the invaded strata into a series of domes, but 'stoped' out portions of the sides and lower surface of the arches, the fragments torn off from walls and roof by the invading granite being found scattered throughout the mass of the invading rock; this 'stoping,' however, probably developed only a small part of the space which the granite now occupies; (5) the invading granite not only exerted a mechanical action upon the invaded strata, but also gave rise to a variety of metamorphic products, among others amphibolite produced by its action in the limestone, which accounts for the fact that while the invaded strata are chiefly limestone, the fragments of the latter, where found in the granite, consist of amphibolite; (6) the invading bathyliths and allied intrusions of granite occupy the greater part of the great Northern Protaxis of Canada, which has an area of approximately 2,000,000 square miles. It has, therefore, been considered advisable to restrict the name Laurentian to this great development of the 'Fundamental Gneiss,' which, although intrusive into the Grenville Series, nevertheless underlies and supports it; (7) the relation of the Grenville Series, which forms the base of the sedimentary portion of the geological column in Eastern Canada, to the Huronian and Keewatin Series, which are the oldest stratified rocks in the western part of the Protaxis, has yet to be determined, the two not having so far been found in contact; nowhere, moreover, either east or west, has the original basement on which the first sediments were laid down been discovered; these are everywhere torn to pieces by the granite intrusions of the Laurentian.

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[1] Communicated by permission of the Director of the Geological Survey of Canada.

At 8 p.m. on Wednesday, November 13th, the actual anniversary of the foundation of the Society in 1807, the Fellows met informally, to the number of about 100, at the Society's Rooms in Burlington House, where the various addresses presented on September 26th were on view.

"The History of the Geological Society of London," by Horace B. Woodward, F.R.S., illustrated with twenty-eight portraits and reproductions of medals, is now obtainable at the Society's Apartments, price 7*s*. 6*d*. nett; and at the reduced price of 6*s*. by Fellows only.

CORRESPONDENCE.

RE CONE-IN-CONE.

Sir,—Touching the origin and age of this formation or structure, would such of your readers as have made observations in this connection kindly tell us at *what depths* below the present surface they have discovered or noted this rock-structure? We know that the Coal-measures contain it, but at what depth in pits (shafts, boreholes, or underground workings) has it been found? Reports state that it occurs in the Cambrian, Lower Silurian, Devonian, as well as in comparatively recent epochs, but the point is: is it as *old* as the strata enclosing it? (See vol. 188, 1894, etc.) W. S. Gresley.

Duffield, Derby.
13th Nov., 1907.

THE ZONES OF THE CHALK.

SIR,—In June last you kindly inserted a notice on the discovery of *Uintacrinus* Chalk in the neighbourhood of Orpington, Kent. Following up my researches, I am pleased to say I have been successful in tracing this zone and the succeeding one of ***Marsupites*** in Holwood Park, Keston, the residence of Lord Derby; and a few weeks ago, in an overgrown pit at Fox Lane, Keston, I discovered the junction bed of the ***Micraster cor-anguinum*** and *Uintacrinus* Chalk.

I hope ere long to give the results of further work in this area and the fauna obtained therefrom. G. E. DIBLEY.

SYDENHAM, S.E.
November 18*th*, 1907.

OBITUARY.

SIR JAMES HECTOR, K.C.M.G., M.D., F.R.S., F.L.S., F.G.S.

BORN 1834. DIED NOVEMBER, 1907.

WE regret to record the death of Sir James Hector, late Director of the Geological Survey of New Zealand and Chancellor of the University of New Zealand. Born in Edinburgh in 1834, he was educated at the University in that city, and took the degree of M.D. in 1856. In the following year he was chosen, through the influence of Sir Roderick Murchison, as surgeon, geologist, and naturalist to accompany Captain John Palliser's exploring expedition to the central parts of British North America. He then made important ethnological and geographical observations, discovered the pass by which the Canadian Pacific Railway now crosses the Rocky Mountains, and afterwards published an important paper on the geology of Lake Superior. In 1861, by Murchison's recommendation, he was appointed geologist to the Provincial Government of Otago, New Zealand, and thenceforth devoted his energies to that country. He became Director of the Geological Survey in 1865, and held the post until 1903. He was elected a Fellow of the Royal Society in 1866, and was created K.C.M.G. in 1887. As a geologist his principal works include Reports on the Coal Deposits, on the Geology of Otago and other parts of New Zealand, and a geological sketch-map of the Islands. The volcanic phenomena and thermal springs, the fossil birds and reptiles, and the recent zoology and botany of New Zealand likewise engaged his attention. He was awarded the Lyell Medal by the Council of the Geological Society in 1877.

MISCELLANEOUS.

THE GEOLOGICAL COLLECTION OF THE LATE JOHN FRANCIS WALKER, M.A., F.L.S., F.I.C., F.C.S., F.G.S.—Having regard to the great value of Mr. J. F. Walker's collection of Brachiopoda and its importance to men of science, Mrs. Walker and her son, Mr. Gelson Walker, have decided to present it to the Trustees of the British Museum. (See obituary in August Number, p. 380.)

INDEX.

ACTINOCAMAX from English Chalk, Two Rare Forms of, 389.
Actinocamax Blackmorei, G. C. Crick, sp. nov., 389.
Adams, Professor F. D., The Laurentian System of Canada, 574.
Africa, South, Bokkeveld Fossils from, 34.
Age of Niagara Falls, Professor J. W. Spencer on, 285.
Alabama, Geological Survey of, 373.
Amaltheus spinatus Zone and Middle Lias, Leicestershire, 462.
Anatifopsis balclatchiensis, F. R. C. Reed, sp. nov., 109.
Andrews, C. W., Vertebrate Remains, Fayûm, Egypt, 97; Cervical Vertebra of *Zeuglodon*, Barton Clay, Hants, 179; Osteology of *Ophthalmosaurus icenicus*, Seeley, 202.
Anglesey, N.E., Glaciation and Physiography in, 348.
Animalium Index, by C. Davies Sherborn, Report on, 509.
Anthracomartus trilobitus, Scudder, Coal-measures, Sparth, near Rochdale, 546, 548.
Arber, E. A. Newell, Fossil Plants from Carboniferous Limestone, Chepstow, 4.
Arenig Rocks in West of Ireland, 84.
Armenia and its Borders, Geological Map of, 567.
Arnold-Bemrose, H. H., Toadstones of Derbyshire, 284.
Arrhenius' Theory of the Physical Causes of Vulcanicity, 173.
Arthropoda from British Coal-measures, Rochdale, Lancashire, 539.
Ashgillian Series, 59, 140, 536.
Australian Artesian Waters, 477.
Australian Geology, in Stanford's Geography, 1907, 423.
Australian Palæontologists on Silurian Ophiurids, 313, 479, 523.
Ayrton, Mrs., Marine Ripple-mark, 191, 287.

BALLYCASTLE Coalfield, Co. Antrim, 85.
Baron, Rev. Richard, Obituary of, 527.
Barry, Sir Francis Tress, Obituary of, 192.
Bather, F. A., Australian Palæontologists on Silurian Ophiurids, 313; on Nathorst's use of Collodion Imprints for Fossil Plants, 437; Nomenclature of Australian Silurian Ophiurids, 523.
"Beagle" Collection, Rocks of, 100.
Bedford, Clay Beds, by the Ouse, 24.
Bellinurus Baldwini, H. Woodw., sp. nov., 540; and *B. longicaudatus*, H. Woodw., sp. nov., M. Coal-measures, Rochdale, Lancashire, 541.
Bennett, F. J., Ightham, the story of a Kentish Village, 234.
Bennett, F. W., Felsites of Charnwood Forest, 470.
Bernese Oberland, Geology of, 43.
Berry, E. W., on Fossil Plants, 42.
Best, Edward, of the Geological Survey, Obituary Notice, 140.
Bicavea rotaformis, Gregory, sp. nov., 442.
Birley, Caroline, Obituary Notice, 143.
Blackheath, Geological Note on, 211.
Bokkeveld Beds, S. Africa, Fauna of, 165, 222; Fossils, S. Africa, 34.
Bolton, H., Marine Fauna in Basement Beds, Bristol Coalfield, 333; Strontia Boulders in Trias, 471.
Bonney, T. G., Southern Origin of Northern Zone in Savoy and Swiss Alps, 237; "Sermons in Stones," 432.
Bosworth, T. O., Origin of Upper Keuper in Leicestershire, 460.
Brachiopod Morphology, S. S. Buckman on, 334.
Brachyurous Crustacean in *Clypeus*-Grit of Cotteswold, 79.
British Association, Leicester, Address to Geological Section, 409, 451; List of Geological Papers read before, 418.
British Trias, Origin of, compared with existing Deserts, 554.

BRÖ

Brögger, W. C., Zones of Neolithic Times, 282.
Brough, B. H., Iron Ore Supplies, 448.
Bryozoa, Rotiform, of the Chalk, 442.
Buckman, S. S., Brachiopod Morphology, 334.

CADELL, H. M., Plant-remains in Olivine Basalt, Bo'ness Coalfield, 219.
Calcareous Nodules, 334.
Canada, Geological Survey, Annual Report, 1901, 89.
Cantrill, T. C., Stratigraphical Note, Haverfordwest, 537.
Cape Colville Peninsula, N.Z., Rocks of, 564.
Carbonate of lime segregated to form nodules, 555.
Carboniferous Limestone, Chepstow, Fossil Plants from, 4; Faunal Succession in the, 70; Anglesey, 238.
Carruthers, R. G., & H. B. Muff, Arenig Rocks in West of Ireland, 84.
Centenary of Geological Society of London, 385, 522.
Century of Geology, A, 1807–1907, The Geological Society of London, 1.
Cephalopods of Cretaceous Rocks of Natal and Zululand, 339.
Cephalopods, Silurian, in the New York State Museum, 45.
Cervical Vertebra of *Zeuglodon*, Barton Clay, Hants, 179.
Chalk, A Case of Metamorphism of, 145.
Chalk and its Dislocation, North Norfolk Geology, 268, 304.
Changes of Physical Constants in Minerals and Igneous Rocks passing from Crystalline to Glassy State, 188.
Chapman, F., Calcareous Nodules, 334; Nomenclature of Australian Silurian Ophiurids, 479.
Charleston Earthquake, 1886, 197.
Charnwood Forest, N.W. District of, 420.
Chemical Composition of Igneous Rocks, 171.
Chemical Reactions between Solids, 379.
Chubb, E. C., & F. P. Mennell, Fossil Mammalia found with Stone Implements, S. Africa, 443.
Clathropteris egyptiaca, A. C. Seward, sp. nov., 253.
Clay Beds by the Ouse, Bedford, 24.
Clayden, A. W., History of Devonshire Scenery, 360.
'Coal-Balls,' Relation of Concretionary Nodules of the Yarra to, 106.

DES

Coalfield, Ballycastle, Co. Antrim, 85.
Coal-measures, Arthropoda from Sparth, Rochdale, 539.
Coal-measures, Ilkeston, Two new species of *Eurypterus* from, 277.
Coastal Features, Co. Waterford, Ireland, 17, 501, 549.
Cole, Grenville A. J., Ballycastle Coalfield, 85.
Collodion as a Preservative for Fossils, 524.
Collodion Imprints of Fossils, Nathorst's use of, 437.
Comparative Fertility of the Soil above certain Geological Formations, 132.
Concretionary Nodules of the Yarra, relation to 'Coal Balls,' 106.
Cone-in-Cone, 575.
Conodonts in Coal-measures, 239.
Constitution of Interior of the Earth revealed by Earthquakes, 376.
Coral Rocks, Barbados, 238.
Corstorphine, G. S., Geological Aspects of South African Scenery, 352.
Cretaceous Formation, Bahia, Brazil, and its Vertebrate Fossils, 93.
Cretaceous, Upper, Fish-remains from Brazil, 193.
Cretaceous Polyzoa (Family Idmoniidæ), A Tabular View of, 122.
Cretaceous Rocks of Natal and Zululand, and Cephalopods of, 339.
Crick, G. C., Cretaceous Rocks of Natal and Zululand, and Cephalopods of, 339; Two Rare Forms of *Actinocamax* from English Chalk, 389.
Crook, T., Titaniferous Volcanic Rocks, 157.
Crustacea from Girvan, Sedgwick Museum Notes, 108.
Crystalline Rocks of Kukuruku Hills, Southern Nigeria, 92.
Crystalline Schists, 328.

DAVIES, A. M., Kimmeridge and Corallian of Brill, Bucks, 46; Collodion as a Preservative for Fossils, 524.
Davison, C., Swansea Earthquake, June 27, 1906, 377; Ochil Earthquakes of September, 1900, to April, 1907, 378.
Deeley, R. M., The Structure of Glacier Ice, 529.
Deformation and Variation in Sea-level, 115.
Desert Conditions and Origin of British Trias, by J. Lomas, 511, 554.
Desert Features, by H. T. Ferrar, 459.

Devonshire Scenery, History of, 360.
Dibley, G. E., *Uintacrinus* in London Basin, 288, 576; Zones of the Chalk, 576.
Diprotodon australis, British Museum, A Reconstructed Skeleton of, 337.
Discovery of Marsupial Plates in *Pygocephalus*, 400.
Dolomites, Overthrust Structure in, 408.
Dorman, S. S., Volcanoes of Basutoland, 463.
Dorset Field Club, Proceedings of, 432.
Dorset Natural History and Antiquarian Field Club, 374.
Douglas, J. A., Changes of Physical Constants in Minerals and Igneous Rocks passing from Crystalline to Glassy State, 188.
Drift Deposits at Kirmington, Lincolnshire, 37, 471.
Du Toit, A. L., Pipe-Amygdaloids, Cape Colony, 13.

EARTHQUAKE, Charleston, 1886, 197.
Egypt, Fossil Plants from, 253.
Eminent Living Geologists: Sir A. Geikie, 1; William Whitaker, 49; Professor H. G. Seeley, 241.
Eoscorpius (*Mazonia*) *Wardingleyi*, H. Woodw., sp. nov., M. Coal-measures, Rochdale, Lancashire, 543.
Etheridge, R., Palæontology of South Australia, 474.
European Animals: Geological History and Distribution, 366.
Eurypterus from the Coal-measures, Ilkeston, 277.
Eurypterus Derbiensis, H. Woodw., sp. nov., 281.
Eurypterus Moyseyi, H. Woodw., sp. nov., 279.
Evans, O. H., Raised Beaches, Taltal, N. Chile, 48.
Evolution of *Stomatopora*, 20.

FAUNA of the Bokkeveld Beds, South Africa, 165, 222.
Faunal Succession in Carboniferous Limestone, Westmoreland, 70; S. W. England, 465.
Fayûm, Egypt, Vertebrate Remains from, 97.
Fearnsides, W. G., Lower Ordovician Succession in Scandinavia, 186, 257, 295; Pisolitic Iron-ores of Wales, 422.
Felsites of Charnwood Forest, 470.
Ferrar, H. T., Some Desert Features, 459.
Fertility of the Soil above certain Geological Formations, Comparative, 132.
Fish-remains from Brazil, Upper Cretaceous, 193.
Fisher, Rev. O., Land-Ice, 48.
Flora of Inferior Oolite of Brora, Sutherland, 376.
Fornaght Strand, Co. Waterford, Coast Features, 17.
Fossil Footprints in Secondary Rocks, 239.
Fossil Mammalia associated with Stone Implements, S. Africa, 443.
Fossil Plants, E. W. Berry, 42; from the Carboniferous Limestone, Chepstow, 4; from S. Africa, 481, 573.
Fossiliferous Drift Deposits, Kirmington, Lincolnshire, 37, 471; and Keuper, Bromsgrove, 28.
Fox-Strangways, C., Geology of Leicestershire, 420.

GARWOOD, E. J., Faunal Succession in the Carboniferous Limestone, 70.
Geikie, Sir Archibald, K.C.B., 1, 432.
Geological Age of Shales of Parys Mountain, Anglesey, 148.
Geological Aspects of S. African Scenery, 352.
Geological Conditions of successful Artesian Boring at Lincoln, 47.
Geological Information about Blackheath, 211.
Geological Map of Ireland, 43.
Geological Society of London, 46, 47, 91, 93, 138, 179, 180, 186, 188, 237, 284, 330, 331, 333, 374, 573.
Geological Society of London: A Century of Geology, by Horace B. Woodward, 1, 385, 575.
Geological Society of London, Centenary of, 385.
Geological Survey of Canada, Annual Report, 1901, 89.
Geological Survey of England: Geology of Hungerford and Newbury, 568.
Geological Survey: Maps and Memoirs, Falmouth, Truro, Camborne, and Redruth, 1906, 175.
Geological Survey Memoirs: Macclesfield, Congleton, etc. (Sheet 110), 39; Wellington and Chard, 1906, 177; Geology of the South Wales Coalfield, 371, 514; Geology of Islay, 476; Country around Swansea, 514; Geology of Leicestershire and S. Derby Coalfield, 516; Geology of Lands End District, 517.

Geological Survey: Summary of Progress of 1905, 41; Drift Maps, 178; Ireland, Memoir and Map, 232; India Report, 1906, 359; of Western Australia, 44; Scotland, New Maps, 1907, 283, 521.
Geologists' Report on Federated Malay States, 565.
Geology of Devonshire, by W. A. E. Ussher, 362.
Geology of India, "The Imperial Gazetteer of India," 1907, 319.
Geology of Oban Hills, S. Nigeria, 92.
Geology of Zambesi Basin, Batoka Gorge, Rhodesia, 138.
Geralinura (?) *Sutcliffei*, H. Woodw., sp. nov., M. Coal-measures, Sparth, Rochdale, 545.
Gimson, M., & W. Keay, Keuper Marls, etc., Bardon Hill, 461.
Glacial Gravels, Holderness, 468.
Glacial History of Nantucket and Cape Cod, 137.
Glaciation and Physiography in N.E. Anglesey, 348.
Glacier Ice, Structure of, R. M. Deeley on, 529.
Gordon, M. M. Ogilvie, Overthrust Structure in the Dolomites, 408.
Gough, Prof. Geo. C., A Case of Metamorphism of Chalk, 145.
Greenly, E., Sandstone Pipes in Carboniferous Limestone, Anglesey, 238; Glaciation and Physiography in N.E. Anglesey, 348; Chemical Reactions between Solids, 379.
Gregory, J. W., Address to Geological Section, British Association, 409, 451; Australian Geology in Stanford's Geography, 423; Rotiform Bryozoa of the Chalk, *Bicavea rotiformis*, sp. nov., 442.
Gresley, W. S., on 'Cone-in-Cone,' 575.
Griesbach, Carl Ludwig, Obituary of, 240.
Grubenmann, Dr. U., Crystalline Schists, 328.
Guernsey, Northern, Rocks of, 74.

HARKER, Alfred, Rocks of the "Beagle" Collection, 100.
Harmer, F. W., Origin of Cañon-like Valleys and Lake-like areas of Depression, 331.
Harrison, J. B., Coral Rocks, Barbados, 238.
Haverfordwest, Base of Silurian near, 535, 537.
Hector, Sir James, Obituary of (1834–1907), 576.
Henslow, G., Xerophytic Character of Coal Plants, 330.
Hickling, G., 'Overfolds' in Relation to Larger Folds, 506.
Hitchcock, C. H., Fossil Footprints in Secondary Rocks, 239.
Hobbs, Professor W. H., Charleston Earthquake, 1886, 197.
Hobson, Bernard, Volcanoes of Nevado de Toluca and Jorullo, Mexico, 5.
Hobson, B., & M. M. Solórzano, Plant-remains in Basalt, Mexico, 217.
Holderness. Glacial Gravels of, 468.
Holland, T. H., Geological Survey, India, Report, 1906, 359.
Holmes, T. V., Recent Geological Information about Blackheath, 211.
Honours to Men of Science, 432.
Hooley, R., Skull and part of Skeleton of *Goniopholis crassidens*, Wealden, Atherfield, Isle of Wight, 46.
Horwood, A. R., Palæontology of North Derby and Notts Coalfield, 421; *Amaltheus spinatus* Zone and Middle Lias, Leicestershire, 462.
Horwood, C. B., Pseudomorphous Pebbles of Pyrites, Crown Reef Mine, Witwatersrand, 187.
"How Long Ago" in Geology, 349.
Howorth, Sir H. H., North Norfolk Geology: The Chalk and its Dislocation, 268, 304.
Hull, E., Geological Conditions to Success of Artesian Boring, Lincoln, 47; Submergence of British Islands, 335.
Hungerford and Newbury, Geology of, 568.
Hunt, A. R., Marine Ripple-mark, 96; Mrs. Ayrton's Theory of Ripple-mark, 287; Saline Solutions and Ores, 525.

IDDINGS, Joseph P., Rock-minerals, 563.
Ightham: the Story of a Kentish Village, 234.
Igneous Rocks, Chemical Composition, 171.
Igneous Rocks to the S.E. of Dartmoor, 331.
Inclusions in Volcanic Rocks, 490.
Index Generum et Specierum Animalium, by C. Davies Sherborn, Report, 509.
India Geological Survey Report (1906), 359.
Inferior Oolite and Contiguous Deposits of Bath-Doulting District, 374.

Inferior Oolite and Contiguous Deposits of Rissington and Burford District, 375.
Invertebrate Animals, Fossil, A Guide to British Museum, Natural History, 518.
Invertebrate Fauna of Uitenhage Series, Cape Colony, 289.
Iowa Geological Survey (1906), 373.
Ireland, Arenig Rocks in West of, 84.
Ireland, Geological Map of, 43.
Ireland, Geological Survey, Memoir and Map, 232.
Iron Ore Supplies, 448.

JOHNSON, J. P., Stone Implements of S. Africa, 372.
Joly, J., Radium in Rocks, 469.
Jorullo and other Volcanoes, noticed by B. Hobson, 5.
Jukes-Browne, A. J., Origin and Age of Plateaus around Torquay, 179; Hills and Valleys of Torquay, 360.

KARROO Beds, Cape Colony, and new Labyrinthodont (*Ptychosphenodon Browni*), 433.
Karroo Beds, S. Africa, Fossil Plants, 573.
Keay, W., & M. Gimson, Keuper Marls, etc., Bardon Hill, 461.
Kentish Village, Ightham, The Story of a, 234.
Keuper, Origin of, in Leicestershire, 460.
Keuper at Bromsgrove, Fossiliferous, 28.
Keuper Marls, etc., Bardon Hill, 461.
Kimmeridge and Corallian of Brill (Bucks), 46.
Kitchin, F. L., Invertebrate Fauna of Uitenhage Series, Cape Colony, 289; A Correction, 480.
Knolls of Limestone, Craven, 36.

LABYRINTHODONT, Karroo Beds, Cape Colony, A New, 433.
Lacustrine Deposit at Hornsea, Post-Glacial, 138.
Lamplugh, G. W., Geology of Zambesi Basin, Batoka Gorge, Rhodesia, 138.
Land-Ice, Rev. O. Fisher, 48.
Lands End District, Geology of, 517.
Lang, W. D., Evolution of *Stomatopora*, 20; A Tabular View of Cretaceous Polyzoa (Family Idmoniidæ), 122; The Selbornian of Stonebarrow, Charmouth, 150.
Lankester, Sir E. Ray, K.C.B., 432.
Laurentian System, The Structure and Relations of, 574.
Leeds, E. Thurlow, Notes on *Metriorhynchus superciliosus*, Desl., 314.
Leicestershire and S. Derbyshire Coalfield, Geology of, 420, 516.
Lichas (*Homolichas*) *melmerbiensis*, F. R. C. Reed, sp. nov., 396.
Life-Zones in Carboniferous Rocks, 465.
Limestone Knolls of Craven, 36.
Lomas, J., Marine Peat, Liverpool, 468; Deserts compared with British Trias, 511, 554.
Love, James, Comparative Fertility of the Soil above certain Geological Formations, 132.
Lowe, H. J., Igneous Rocks south-east of Dartmoor, 331.

MACCLESFIELD, Congleton, etc., Geology of, 39.
McKay, Alexander, & Professor W. J. Sollas, Rocks of Cape Colville, New Zealand, 564.
Maclaren, M., Australian Artesian Waters, 477.
Malay States, Federated, Geology of the, 565.
Marine Fauna in Basement Beds, Bristol Coalfield, 333.
Marine Peat, Liverpool, 468.
Marine Ripple-mark, 96, 191.
Marr, J. E., "Ashgillian Series," 59, 536.
Martin, E. A., "How Long Ago" in Geology, 349.
Maryland Geological Survey, 1906, 372.
Matthew, Dr. W. D., Relationship of the Sparassodonta, 531.
Memoirs of Geological Survey, 39, 175, 177, 232, 360, 371, 476, 514, 516, 517, 521, 568.
Mennell, F. P., Somabula Diamond Field, 95.
Mennell, F. P., & E. C. Chubb, Fossil Mammalia with Stone Implements, S. Africa, 443.
Metamorphism of Chalk, A Case of, 145.
Metriorhynchus superciliosus, Desl., 314.
Mexico, Plant-remains in Basalt of, 217.
Middle Lias, Leicestershire, 462.
Mineralogical Society, London, 94, 189, 286, 378.
Mines and Minerals, "Indian Empire" (1907), 325.
Moberg, J. C., & C. O. Segerberg, Tremadocian Series, Sweden, 85.

Mojsisovics von Mojsvar, Edmund, Death of, 527.
Muff, H. B., & R. G. Carruthers, Arenig Rocks in West of Ireland, 84.

NANTUCKET and Cape Cod, Glacial History of, 137.
Nathorst's use of Collodion Imprints for Fossil Plants, 437.
Nevado de Toluca and Jorullo, Mexico, Volcanoes of, 5.
New Dinosaur from Trias, Lossiemouth, Elgin, 93.
New York State Museum, Silurian Cephalopoda in, 45.
New Zealand, Rocks from Cape Colville, 564.
Newbury and Hungerford, Geology of, 568.
Niagara Falls, Recession of, 440.
Nomenclature of Australian Silurian Ophiurids, 479, 523.
Norfolk, North, Geology: The Chalk and its Dislocation, 268, 304.

OBITUARY: Sir Francis Tress Barry, 192; Rev. Richard Baron, 527; Edward Best, 140; Miss Caroline Birley, 143; Carl L. Griesbach, 240; Sir James Hector, 576; Professor E. Mojsisovics, 527; Professor Charles Stewart, 527; John Francis Walker, 288, 380; John Ward, 141.
Ochil Earthquakes of September, 1900, to April, 1907, 378.
Oldham, R. D., Constitution of Interior of Earth revealed by Earthquakes, 376.
Olivine Basalt, Bo'ness Coalfield, Plant-remains in, 219.
Ophthalmosaurus icenicus, Osteology of, 202.
Ordovician, Lower, Scandinavia, 186, 257, 295.
Ordovician System, Ashgillian Series, 59.
Origin and Age of Plateaus around Torquay, 179.
Origin of Cañon-like Valleys and Lake-like Areas of Depression, 331.
Osmundites Kolbei, A. C. Seward, sp. nov., 482.
Osteology of *Ophthalmosaurus icenicus*, 202.
Oswald, Felix, Geological Map of Armenia, etc., 567.
Overfolds in Relation to Larger Folds, 506.
Overthrust Structure in the Dolomites, 408.

PALÆONTOGRAPHICAL Society, 190.
Palæontology, The Progress of, Pal. Soc., 1906, 134.
Palæontology of N. Derby and Notts Coalfield, 421.
Parkinson, J., Rocks of Northern Guernsey, 74; Post-Cretaceous Stratigraphy of S. Nigeria, 91; Crystalline Rocks of Kukuruku Hills, S. Nigeria, 92; Geology of Oban Hills, S. Nigeria, 92.
Parys Mountain, Anglesey, Geological Age of Shales of, 148.
Pearson, H. W., Deformation and Variation in Sea-level, 115.
Permo-Carboniferous Plants from South Africa, 481.
Phyllotheca Whaitsii, A. C. Seward, sp. nov., 481.
Pinnocaris curvata, F. R. C. Reed, sp. nov., 110.
Pipe-Amygdaloids, Cape Colony, 13.
Pisolitic Iron-ores of Wales, 422.
Plant-remains in Basalt, Mexico, 217.
Plant-remains in Olivine Basalt, Bo'ness Coalfield, 219.
Plants, Fossil, from S. Africa, 481, 573, 574.
Plants, Fossil, South Africa, from the Karroo, 573.
Plants from Egypt, Fossil, 253.
Polyzoa (Family Idmoniidæ), A Tabular View of Cretaceous, 122.
Post-Cretaceous Stratigraphy of South Nigeria, 91.
Pre-Devonian Beds of the Mendips, 510.
Prosopon, Stratigraphical Position of, 82.
Prosopon in *Clypeus*-Grit, Cotteswold, 79.
Prosopon Richardsoni, H. Woodw., sp. nov., 79.
Pseudomorphous Pebbles of Pyrites, Crown Reef Mine, Witwatersrand, 187.
Ptychosphenodon Browni, H. G. Seeley, gen. et sp. nov., 433.
Pygocephalus, a primitive Schizopod Crustacean, Coal-measures, 400.
Pygocephalus (*Anthrapalæmon*) *Parkeri*, H. Woodw., sp. nov., Coal-measures, Sparth, 406.

RADIUM in Rocks of Simplon Tunnel, 469.
Raised Beaches, Taltal (N. Chile), 48.
Rastall, R. H., Arrhenius' Theory of the Physical Causes of Vulcanicity, 173.
Recession of Niagara Falls, 440.
Reclus, Élisée, Volcanoes of the Earth, 236.

Reed, F. R. Cowper, Coastal Features, Fornaght Strand, Co. Waterford, 17, 501, 549; Fauna of the Bokkeveld Beds, S. Africa, 34. 165, 222; Ashgillian Series, 140. Sedgwick Museum Notes: Crustacea, Girvan, 108; *Sladina cateniformis*, Haverfordwest, 208; A New Species of *Lichas*, 396; Base of Silurian, Haverfordwest, 535.
Relationship of 'Sparassodonta,' 531.
Reports and Proceedings: Dorset Natural History Field Club, 374; Geological Society, 46, 47, 91, 93, 138, 179, 180, 186, 188, 237, 284, 330, 331, 333, 374; Centenary of Geol. Soc., 522; Mineralogical Society, 94, 189, 286, 378; Palæontographical Society, 190; Zoological Society, 190.
Reynolds, S. H., Pre-Devonian Beds of the Mendips, 510; Silurian Inlier in Eastern Mendips, 188.
Rhinoptera prisca, A. S. Woodward, sp. nov., 195.
Richardson, L., Stratigraphical Position of *Prosopon*, 82; Inferior Oolite and Contiguous Deposits of Bath-Doulting District, 374; Inferior Oolite and Deposits of Rissington and Burford District, 375.
Rochdale, Lancashire, Arthropoda from Coal-measures, 405, 406, 539.
Rock-minerals, by Prof. J. P. Iddings, 563.
Rocks of Cape Colville Peninsula, New Zealand, 564.
Rocks of Northern Guernsey, 74.
Rocks of the "Beagle" Collection, 100.
Rosenbusch, H., Commemoration Volume of 70th Birthday, 363.
Rotiform Bryozoa of Chalk, 442.
Ruedemann, R., Cephalopoda, New York State Museum, 45.

SALINE Solutions and Ores, 525.
Sandstone Pipes in Carboniferous Limestone, Anglesey, 238.
Scandinavia, Lower Ordovician Rocks, 257, 295.
Scharff, R. F., European Animals: Geological History and Distribution, 366.
Schizopod Crustacean, *Pygocephalus*, Coal-measures, 400, 405, 407.
Schwarz, Ernst H. L., Tygerberg Anticline, 487.
Scotland, Geological Survey, New Maps, 1907, 283.
Scrivenor, J. B., Geologists' Report on the Federated Malay States, 565.
Sea-level, Deformation and Variation, 115.
Sedgwick Museum Notes: Crustacea from Girvan, 108; *Sladina cateniformis*, Haverfordwest, 208; A New Species of *Lichas*, 396; Silurian, Haverfordwest, 535.
Seeley, H. G., Eminent Living Geologists, 241; New Labyrinthodont, Karroo Beds, Cape Colony, 433.
Segerberg, C. O., & J. C. Moberg, Tremadocian Series, Sweden, 85.
Selbornian of Stonebarrow Cliff, Charmouth, 150.
"Sermons in Stones," 432.
Serviço Geologico e Mineralogico do Brazil, 528.
Seward, A. C., Fossil Plants, Egypt, 253; Fossil Plants from S. Africa, 481, 573; Permo-Carboniferous Plants, Vereeniging, South Africa, 573.
Shattuck, G. B., Maryland Geological Survey, 1906, 372.
Sheppard, T., Post-Glacial Lacustrine Deposit at Hornsea, 138.
Sheppard, T., & J. W. Stather, Glacial Gravels, Holderness, 468.
Sherborn, C. D., Index Generum et Specierum Animalium, 509.
Skeleton of *Diprotodon australis*, Owen, British Museum, 337.
Skull and part of Skeleton of *Goniopholis crassidens*, Wealden, Atherfield, I. of Wight, 46.
Silurian, Base of, near Haverfordwest, 535, 537.
Silurian Inlier in Eastern Mendips, 188.
Silurian Ophiurids, Australian Palæontologists on, 313.
Sladina cateniformis, F. R. C. Reed, gen. et sp. nov., Haverfordwest, 208.
Smith, J., Conodonts in Coal-measure Strata, 239.
Sollas, Professor W. J., & Alexander McKay, Rocks of Cape Colville, New Zealand, 564.
Solórzano, M. M., & B. Hobson, Plant-remains in Basalt, Mexico, 217.
Somabula Diamond-field, F. P. Mennell, 95.
South Africa, Fossil Plants from, 481, 573, 574.
South Africa, Pipe-Amygdaloids, 13.
South African Scenery, Geological Aspects of, 352.
South Australia, Palæontology of, 474.
South Wales Coalfield, Geology of the, 371, 514.

Southern Origin of Northern Zone in Savoy and Swiss Alps, 237.
Sparassodonta, Relationship of the, 531.
Spencer, J. W. W., Age of Niagara Falls, 285; Recession of Niagara Falls, 440.
Stanford's Geography: Australian Geology, 423.
Stather, J. W., Drift Deposits at Kirmington, 37, 471.
Stather, J. W., & T. Sheppard, Glacial Gravels, Holderness, 468.
Stewart, Prof. Charles, Obituary of, 526.
Stomatopora, Evolution of, 20.
Stone Implements associated with Fossil Mammalia, South Africa, 443.
Stone Implements of South Africa, 372.
Stonebarrow Cliff, Charmouth, The Selbornian of, 150.
Stopes, M. C., Relation of Concretionary Nodules of the Yarra to 'Coal-Balls,' 106,; Flora of Inferior Oolite of Brora, Sutherland, 376.
Stracey, B., Charnwood Forest, North-West District, 420.
Strahan, A., Geology of South Wales Coalfield, 1907, 371.
Stratigraphical Note on Slade Beds, Haverfordwest, 537.
Stratigraphical Position of *Prosopon Richardsoni*, H. Woodw., sp. nov., 82.
Strontia Boulders in Trias, near Bristol, 471.
Structure of Glacier Ice, 529.
Submergence of British Islands, 335.
Summary of Progress of Geological Survey for 1905, 41.
Swansea Earthquake (June 27th, 1906), 377.
Swiss Geology, Bernese Oberland, 43.

THOMPSON, Beeby, Clay Beds by the Ouse, Bedford, 24.
Thomson, J. A., Inclusions in Volcanic Rocks, 490.
Titaniferous Volcanic Rocks, 157.
Toadstones of Derbyshire, 284.
Torquay, Hills and Valleys of, by A. J. Jukes-Browne, 362.
Tremadocian Series, Sweden, 85.
Trias compared with modern Deserts, 554.
Tygerberg Anticline, Professor E. H. L. Schwarz, 487.

UINTACRINUS in the London Basin, 288, 576.
Uitenhage Series, Cape Colony, Invertebrate Fauna of, 289.
Ussher, W. A. E., Geology of Devonshire, 362.

VERTEBRATE Remains, Fayûm, Egypt, 97.
Volcanic Rocks, Inclusions in, 490.
Volcanic Rocks, Titaniferous, 157.
Volcanoes of Basutoland, 463.
Volcanoes of the Earth, Elisée Reclus, 236.
Volcanoes of Nevado de Toluca and Jorullo, Mexico, 5.
Vulcanicity, Arrhenius' Theory of Physical Causes of, 173.

WADE, Arthur, Chemical Composition of Igneous Rocks, 171.
Walcott, C. D., Appointed Secretary of the Smithsonian Institute, 287.
Walker, John Francis, Obituary of, 288, 380; his Collection of Brachiopoda given to National Museum, 576.
Ward, John, Longton, Staffs, Obituary of, 141.
Waterford Co., Ireland, Coast Features, 17, 501, 549.
West. Australia, Geological Survey of, 44.
Whitaker, William, Eminent Living Geologists, 49.
White, H. J. O., Geology of Hungerford and Newbury, 568.
Wilkinson, S. B., Geology of Islay, 476.
Williams, G. J., Geological Age of Shales, Parys Mountain, Anglesey, 143.
Wills, L. J., Fossiliferous Keuper, Bromsgrove, 28.
Wilmore, A., Limestone Knolls, Craven, 36.
Wilson, J. H., Glacial History of Nantucket and Cape Cod, 137.
Woodward, A. S., Cretaceous Formation, Bahia, Brazil, and its Vertebrate Fossils, 93; New Dinosaur, Trias, Lossiemouth, Elgin, 93; Upper Cretaceous Fish-remains from Brazil, 193; A Reconstructed Skeleton of *Diprotodon australis*, Owen, British Museum, 337.
Woodward, Henry, *Prosopon* in *Clypeus*-Grit, Cotteswold, 79; Two new species of *Eurypterus*, Coal-measures, Ilkeston, 277; *Pygocephalus*, a primitive Schizopod Crustacean, in Coal-measures, 400; Further Notes on Arthropoda in British Coal-measures, 539.
Woodward, H. B., History of the Geological Society, London, 385, 575.

XEROPHYTIC Character of Coal Plants, 330.

ZONES of Neolithic Times, 282.
Zones of the Chalk, 576.
Zoological Society, 190.

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